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DRIVERS OF MARKET LIQUIDITY AND TRADING ACTIVITY ON HELSINKI STOCK EXCHANGE

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ABSTRACT
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Objective of the study

The study concentrates on market-wide liquidity measures and their time series qualities on Helsinki Stock Exchange. The first objective was to formulate market-wide liquidity measures and study their time series qualities. The second objective was to research determinants of movements of market liquidity and test their explanatory power. Potential determinants were identified and research hypotheses formed based on current literature and a priori reasoning.

Research data

Scientific literature related to liquidity on financial markets was used in the study. As empirical test data bid and ask quotes, trading volume and several macroeconomic variables during 1990-2000 were used.

Research methodology

Market-wide trading volume and bid-ask spreads composed as an arithmetic average or a value-weighted average of spreads of independent stocks were used as liquidity measures. Time-series qualities of daily, weekly and monthly changes of the liquidity measures were studied, and their connection with the used explanatory variables was tested with linear regression models. Typical violations from data requirements of linear regression models were controlled.

Results of the study

Aggregate bid-ask spreads and trading volume are even more volatile than market returns. Daily, weekly and monthly changes in liquidity measures are negatively autocorrelated and deviate from normal distribution. During the 1990's liquidity on Helsinki Stock Exchange has increased considerably, potentially due to institutional changes and is a notable rise in equity prices from the beginning of the 1990's. The determinants investigated explain between 20 and 28 percent of monthly, between 17 and 19 percent of weekly and between 14 and 17 percent of daily changes in market liquidity. The most important cross-sectional determinants among the tested ones are market returns, market volatility and seasonal dummies.

Keywords

Liquidity, Spread, Time series, Volume, Security markets

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DRIVERS OF MARKET LIQUIDITY AND TRADING ACTIVITY ON HELSINKI STOCK EXCHANGE

Tutkimuksen tavoitteet

Tutkimus keskittyy koko osakemarkkinoita kuvaaviin likvidimittareihin ja niiden aikasarjaominaisuuksiin Helsingin arvopaperipörssissa. Tutkimuksen ensimmäinen tavoite oli muodostaa koko markkinoita kuvaavia likviditeettimittareita ja tutkia niiden aikasarjaominaisuuksia. Toinen tavoite oli tutkia likviditeettimittareiden aikasarjamuutosten selittäviä tekijöitä ja testata niiden selitysvoimaa tilastollisin menetelmin. Potentiaaliset selittäjät määritettiin aiheeseen liittyvän kirjallisuuden ja järkeilyn avulla.

Lähdeaineisto

Rahoitusmarkkinoiden likviditeettiä kuvaavaa kirjallisuutta käytettiin tutkielmassa. Empiirisenä tutkimusaineistona käytettiin osakkeiden osto- ja myyntitarjouksia, osakevaihtoa, hintanoteerauksia ja erilaisia makrotaloudellisia indikaattoreita vuosilta 1990-2000.

Aineiston käsittely

Koko markkinoiden osakevaihtoa ja osakekohtaisten osto myynti- ja ostotarjousten välisen eron aritmeettista ja arvopainotettua keskiarvoa käytettiin likviditeettimittareina. Näiden mittareiden päivittäisten, viikottaisten ja kuukausittaisten muutosten aikasarjaominaisuuksia tutkittiin ja niiden tilastollinen yhteys potentiaalisiin selittäviin tekijöihin testattiin lineaarisilla regressiomalleilla.

Tulokset

Käytettyjen likviditeettimittareiden volatiliteetti on suurempi kuin osaketuottojen. Likviditeettimittareiden muutokset ovat negatiivisesti autokorreloituneita ja poikkeavat normaalijakaumasta. Käytettyjen mittareiden perusteella markkinalikviditeetti on kasvanut Helsingin arvopaperipörssissä huomattavasti, mahdollisesti pörssikurssien nousun ja institutionaalisten muutosten takia. Käytetyt tekijät selittävät 20-28 % kuukausittaisesta, 17-19 % viikottaisesta ja 14-17 % päivittäisestä likviditeetin vaihtelusta. Tärkeimmät selittävät tekijät ovat osaketuotot, niiden volatiliteetti ja kausiluonteisuuten perustuvat dummy-muuttujat.

Avainsanat

Likviditeetti, osakevaihto, osakemarkkinat

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1 Introduction

1.1 Background and motivation of the study

Liquidity, easiness of converting an asset into cash, is in many ways important for investors, directors of finance and officials.

Liquidity is one of the primary attributes of securities and investment decisions, in addition to e.g. risk and investment horizon. Liquid assets are easily traded. Then single investors can expect to find counterparties, which are immediately ready to trade at valid intrinsic prices. However, trade in illiquid assets is much more difficult. A suitable counterparty for trades cannot be found easily, and due to minor trading and small competition between traders instant trading probably requires accepting a weaker price causing higher trading costs. As investors care about expected holding period returns net of trading costs, ceteris paribus investors prefer liquid securities before illiquid ones. This should in theory cause a negative association between asset liquidity and returns, as investors demand a premium for illiquid securities (Amihud and Mendelson 1986). This theory is also supported by empirical evidence of equity and bond markets (see e.g. Datar et al. 1998, Eleswarapu 1997, Amihud and Mendelson 1986, 1989, 1991a). This connection should also interest companies that try to maximize their shareholder value: liquidity-increasing financial policies should increase value of companies.

Liquidity has also contributed to many abnormal events in securities markets. For instance, Grossmann and Miller (1988) interpret that the famous international equity market crash of October 1987 was entirely, or even primarily, a matter of liquidity rather than of fundamentals: market were not liquid enough to handle the flow of sell orders without a notable price impact. Chordia et al. (2000) suggest that the global bond market also seemed to undergo a similar liquidity-related crisis during the summer 1998, caused by sudden pervasive changes in liquidity.

Further, liquidity-related issues interest officials, who design marketplaces and monitor them. Considerable agreement exists that fully informed prices are important goal of security exchanges. This should improve optimal allocation of capital from the view of whole economies. Impact of different trading mechanisms on the interaction between traders and price determination has been approached in market microstructure studies. One common assumption in these models is that sufficient liquidity improves price informativeness. Therefore, sufficient liquidity is necessary for exchanges to reach the goal of informative prices. (Hedvall 1994: 6-7).

Generally, exchange organizations, regulation and investment management could all be improved by knowledge of factors that influence liquidity and trading activity.

Liquidity, like many other securities market parameters as asset returns, return volatility or risk premia is not a constant independent of time. Theoretical models of e.g. Kyle (1985), Admati & Pfleiderer (1988) and Foster & Viswanathan (1990) describe the dynamic, varying nature of liquidity and trading volume. Empirical evidence concerning variability of liquidity-related variables and is presented by e.g. Jones et al. (1994), Hedvall (1994) and Draper & Paudyal (1997). However, despite of the importance of liquidity, studies of liquidity usually have had some deficiencies and this has left current knowledge of liquidity behaviour over time relatively limited. (Chordia et al. 2001)

First, empirical studies have often concentrated on liquidity qualities of individual securities. Much of the knowledge of determinants of liquidity is based on theoretical and empirical studies of factors causing liquidity differences between individual shares, like Demsetz (1968), Garman (1976), Stoll (1978a, 1978b), Glosten and Milgrom (1985) and Hansson (1995). Empirical studies of trading and liquidity patterns are usually concentrated on individual assets, like Wood et al. (1985) and Harris (1991). Also impact of different events, e.g. large trades (Chan and Lakonishok 1997) or share distributions (Hansson 1999) on liquidity of individual securities have been typical in research.

Second, based on literature research of Chordia et al. (2001) empirical studies on liquidity have concentrated on relatively short time spans of a year or less. Chordia et al. also argue that liquidity has in many studies regarded as a relatively fixed property of an asset, not observing the mentioned variability over time.

These problems have been approached by Hasbrouck & Seppi (1998), Huberman & Halka (1999) and Chordia et al. (2000), who document commonality in the time series movements of liquidity attributes, i.e. liquidity attributes of individual securities tend to co-move. Similar papers concentrating on commonalities in market volume are presented by Pettengill & Jordan (1988) and Lo & Wang (1999). Chordia et al. (2000) suggest that there exists some market-wide factors contributing to this behaviour. However, the authors did not aim to identify these factors. Probably the first paper concentrating on these determinants of changes in market-wide liquidity was written by Chordia et al. (2001), who aimed to answer the following questions: How does aggregate, market-wide liquidity behave over time? Are there regularities in time series of liquidity? What external factors cause movements of aggregate liquidity?

If concept of liquidity is expanded to cover also trading volume, academic interest in these issues has been more intensive. Empirical papers of determinants of trading volume have been much more usual, e.g. Karpoff (1987) and Lakonishok & Smidt (1989). Especially papers exploring association between trading volume and asset price changes have been numerous.

I still find the previous questions important and relatively unexplored. In addition to academic interest in market-wide liquidity and its determinants, these questions are important for investors developing trading strategies and exchange officials attempting to identify conditions likely to disturb trading activity. For instance, transaction costs of investors could be better managed with appropriate timing. When liquidity is good, managed portfolio turnover can be higher without sacrificing performance. Knowledge of conditions causing changes in trading volume may also be interesting for banking firms, whose revenues from brokerage are highly dependent on trading activity.

1.2 Research problems of the study

This study discusses market-wide, aggregate liquidity movements on the Helsinki Stock Exchange during 1990-2000. The research problems can be presented as the following questions:

1. How do market liquidity indicators behave over time?
2. What factors are related to movements of market liquidity?

The first research problem concerns movements of aggregate market liquidity. The objective is to formulate market-wide liquidity measures and study their time series qualities. In addition to time series qualities, seasonalities typical to other share market attributes are also searched (for discussion of seasonality behaviour of share markets see e.g. Draper and Paudyal 1997). In this study, value-weighted and arithmetic averages of bid-ask spreads of individual securities and market trading volume are used as liquidity measures.

The second research problem concerns determinants of movements of market liquidity. Potential determinants are identified and research hypotheses formed based on current literature and a priori reasoning. A priori reasoning is partly needed, as explicit theoretical models covering the research problems are relatively few (Chordia et al. 2001). Potential determinants are based on different macroeconomic variables and stock market performance, i.e. market returns and volatility. Association between aggregate liquidity movements and potential determinants is studied with linear statistical models.

1.3 Contribution of the study

All the research on financial markets is somehow dependent on design and market microstructure of the security market under investigation. This is especially evident considering the theme of this study, market liquidity. Based on literature, liquidity and market microstructure have certain interdependence. Studies of impact of different market microstructure and trading methods on liquidity have been presented by e.g. Amihud and Mendelson (1991b), Madhavan (1992) Hedvall (1994), Glosten (1994), Pagano and Röell (1996), Schnitzlein (1996) and Käppi and Siivonen (2000). Therefore, results based on liquidity studies on a certain security market are not necessarily consistent in other securities markets.

Major body of knowledge of liquidity consists of studies on the U.S. securities markets. Studies on Helsinki Stock Exchange are important, as it clearly differs from the U.S. institutional and market structures. Possibly one of the most evident differences concerns trading mechanisms. On New York Stock Exchange and Nasdaq specialists maintain a market by operating as brokers and buying and selling securities from their own inventories whereas Helsinki Stock Exchange lacks designated market makers. Helsinki Stock Exchange is a small limit order book market, where trading is solely based on limit orders submitted by brokers. Compared to the major U.S. securities markets, relatively low trading volume is also characteristic for Helsinki Stock Exchange, especially concerning statistics from the beginning of the 1990's. Considering this difference, it is interesting to compare the results documented in U.S. studies. This may also help to understand how sensitive U.S. results are for changes in market microstructure.

Similar empirical studies as this have not yet been conducted on Finnish market. Hansson (1994) conducted an extensive study of Finnish market microstructure, but research problems of this study were not answered. Determinants of bid-ask spread differences between Finnish equities were studied by Hansson (1995), but used-time span was short and focus was on single shares. Lintukangas (2002) also mainly concentrated on cross-sectional liquidity differences between stocks utilizing price impact measure.

Bergholm and Liljeblom (1990) analyzed contemporaneous connection between trading volume and share market return distributions, but the time frame was relatively limited and covered only the years Helsinki Stock Exchange was using totally different trading mechanism from the one during the 1990's. Traditional price change - volume relation widely described in literature (see e.g. Karpoff 1987) is also quite rarely studied on Finnish market. The issue is chiefly approached by Bergholm and Liljeblom (1990), Martikainen et al. (1994) and Liljeblom and Stenius (1997) using aggregate market volume and market indices. However, other liquidity measures and their drivers were not contemplated. Additionally, most of the data in their studies is from the days of old batch auction –based system. Grinblatt and Keloharju (2001) have researched several factors impacting trading activity, but this study concerns trading decisions of individual investors, not market-wide measures.

Internationally the same research problems have been approached primarily by Chordia et al. (2001), but as an extension for their study different measuring frequency of share market data is used. Chordia et al. used days as data frequency. However, statistical qualities of share market data may strongly depend on data frequency. One of the most clearest examples of this concerns autocorrelation coefficients of share market returns on the U.S. markets: in the short run coefficients are usually positive, but turn negative in the long run (Bodie et al. 1999: 344-346). In this study also weeks and months are used as data frequency.

For these reasons, I find this study important especially from the viewpoint of small, limit order book markets and argues that it contributes to the current knowledge of how equity markets work.

1.4 Structure of the study

The study is organized as follows.

In chapter 2. basic concepts related to liquidity and liquidity formation in securities markets are described.

In chapter 3. potential explanatory factors impacting on market liquidity changes are presented based on literature. Chapter 3. also includes the research hypotheses.

Used statistical research methods and data are discussed in chapter 4. Results are presented and analyzed in chapters 5. and 6.

2 Basic concepts of formation of liquidity

In this chapter some general issues concerning liquidity and security trading processes impacting on it are presented. These factors are very important in liquidity-related studies, because liquidity and market microstructure have certain interdependence. Studies of impact of different market microstructure and trading methods on liquidity have been presented by e.g. Hedvall (1994), Pagano and Röell (1996), Schnitzlein (1996), Glosten (1994), Amihud and Mendelson (1991b), Madhavan (1992) and Käppi and Siivonen (2000).

2.1 Different security trading methods

2.1.1 Basic classification of security trading methods

In practise there are considerable differences between stock trading methods. For instance, on New York Stock Exchange risk-assuming dealers play an important part in trading. Traders can obtain price quotations before trading from them and can be sure about terms of trade beforehand. By contrast e.g. traders on Helsinki Stock Exchange post their offers before prices are determined.

Madhavan (1992) studied differences between trading methods. According to Madhavan, price discovery, i.e. the process of finding market-clearing prices, differs notably between trading methods. He suggests the classification between trading methods according to two factors. First, trading mechanisms can be either continuous or periodic. Second, mechanisms can be quote-driven or order-driven.

In a continuous market investors' orders are executed immediately. According to Madhavan, this system is characterized by "a sequence of bilateral transactions at (possibly) different prices". On the contrary, in security exchanges utilizing periodic methods investors' orders are accumulated for simultaneous execution at a predetermined time. This method is also called as a call auction or batch market. In this system, multilateral transactions typically take place at one price.

Naturally, most trading mechanisms are combinations of mentioned simplified processes. For instance, trading on NYSE opens with a call auction and then continues as a continuous market. There are also other ways to classificate securities markets (see. e.g. Bodie et al. 1999: 67-95, Pagano & Roell 1996).

2.1.2 Quote-driven dealer markets

In a quote-driven system such as International Stock Exchange (London) or Nasdaq investors can obtain firm price quotations from market makers prior to order submission. This mechanism is also called as a continuous dealer market, as investors do not have to wait for their trade execution but instead can trade with a market maker. (Madhavan 1992)

For instance, on NYSE specialists are central in trading. They have a duty to maintain a market of one or more listed securities. There is only one specialist per stock on NYSE. Maintaining a market requires specialists to operate as a broker and as a dealer. Specialists' role as a broker is simply to execute orders of other brokers. However, in some occasions maintaining an orderly market requires specialists also operate as dealers. As dealers specialists buy and sell securities from their own inventories and quote bid and asked prices at which they are obligated to meet at least a limited amount of market orders. Bid and ask quotations typically depend on the size of the order. Market orders are simply buy or sell orders that are to be executed immediately at current quoted market prices. This enables investors to trade even during occasions, when no other investors are interested in trading the security in question. In addition to market orders investors may choose to use limit orders, whereby they specify prices at which they are willing to buy or sell a certain amount of security. If price falls below the limit on a limit-buy order or above the limit on a limit-sell order the trade is to be executed. (Bodie et al. 1999: 76-78)

2.1.3 Order-driven markets and LOB systems

In order-driven systems traders post their orders for execution through an auction process as distinct from quote-driven systems. Systems can be continuous or periodic. In continuous auctions investors post their orders for immediate execution by brokers on an exchange floor or against existing limit orders submitted by public investors or dealers. The system can be regarded as continuous, since orders are processed upon arrival, but operates as an auction because prices are determined multilaterally. This system is used for instance on Paris Bourse and Frankfurt Stock Exchange. In periodic auctions investors' orders are stored for execution at a single market price later. Periodic auctions are typically used to open many continuous markets, e.g. NYSE and Tokyo Stock Exchange. (Madhavan 1992)

In this classification Helsinki Stock Exchange also belongs to continuous auction systems. Also terms COLOB (continuous limit order book) or shorter LOB (limit order book) are often used in this context. The first COLOB system used at a major exchange was the CATS system on Toronto Stock Exchange. Later similar systems have been used by several stock exchanges, e.g. Paris, Brussels and Barcelona. Also some derivatives markets, like DTB in Germany, OM in Sweden and SOFFEX in Switzerland have used CATS-based systems. (Hedvall 1994: 4-5)

On LOB markets liquidity is provided by limit orders submitted in the book by brokers, who are members of the exchange. Orders are placed in order in price and time priority, and contents of the order book for a particular security are visible to all brokers via computer screens. Usually there exists no designated liquidity providers like specialists on NYSE: investors submit their orders to brokers, who submit them further to computerized, continuous auctions. In these auctions incoming buy and sell orders are matched and market price is determined. Hence, in this trading method unavailability of other investors prevents trades of a single investor, because liquidity is solely provided by the limit order book. (Hedvall 1994: 4-5)

A more detailed case example of LOB-based trading, Helsinki Stock Exchange, is provided in chapter 4, in connection with other research data.

2.2 Liquidity and liquidity measures

2.2.1 What is liquidity?

Liquidity is necessarily not an easy concept to measure or define. Probably the easiest definition is presented by Hasbrouck and Schwartz (1988): “An asset is liquid, if it can be converted to cash easily”. However, this simple definition raises several questions. What does ease of conversion mean? How can it be measured? Hasbrouck and Schwartz suggest that ease of conversion can be measured by the time required to trade an asset for cash at a reasonable price or by the cost of trading an asset for cash quickly. The latter measurement is probably preferable for financial securities that normally can be traded without appreciable delay in a modern securities market. Still, on many other markets delay and search costs can be substantial. Delay and search costs may include the costs to find and contact potential trading partners and risks of the delay borne by the investor who seeks better terms for execution of the transaction.

Black (1971) sets the following requirements for a liquid market. First, there should always be bid and asked prices for the investor, who wants to buy or sell small amounts of security immediately. Second, the difference between bid and asked prices is always small. Third, an investor buying or selling a large amount of securities, in the absence of special information, can expect to do so over a long period of time at a price very near the current market price. Fourth, an investor can trade a large amount of securities immediately, but at a premium. In liquid security markets single trades also should have a small price impact.

Measuring liquidity is further complicated by the fact that liquidity requirements of different investors are not always similar. Hansson (1999: 14) illustrates this perspective assuming a security market characterized by frequent, but small limit-orders submitted to the order book. An investor committing small trades may consider the market liquid, as he probably gets his trades executed quickly at a competitive price. On the other hand, a larger trader might find it difficult to get a big trade executed, if the order flow consists of small trades.

Hasbrouck and Schwartz (1988) also suggest that liquidity requirements depend on trading strategies. Passive traders like to use limit orders, and wait for the contra side of the market to come to them. They probably try to avoid execution costs and aim to minimize them. On the other hand, active traders seek to immediate transactions with market orders. Active traders emphasize fast trading before transaction costs.

Based on these examples liquidity is not an unambiguous concept. However, there are some widely used quantitative measures.

2.2.2 Bid-ask spread and transaction costs

One of the most usual liquidity measures is a bid-ask spread, a difference between bid and asked prices.

Existence of difference between quoted bid and ask prices of market makers is very natural in dealer markets. Market makers and dealers incur costs of their activity. Role of market makers as brokers requires order-processing related costs. On exchanges trading on the floor also requires memberships, which are expensive investments. For instance, a record price paid for NYSE membership is USD 2.65 million (NYSE 2001). Holding an inventory of securities also causes costs. Therefore dealers are compensated for the costs by selling at an ask price (above the "true price") and buying at a bid price (below the "true price").

Grossman and Miller (1988) regard bid-ask spread as a price of immediacy in dealer markets. Investors face a trade-off in securities markets. For instance, instead of turning to dealers submitting a market-sell order investors can choose a limit order: by waiting until more potential buyers have been notified, the seller increases the chance to find more potential buyers. But this option also carries risks. The best selling price for a sale delayed to the second period may be substantially lower (or higher) than a price in a sale to a market maker in the first period. Grossman and Miller argue that willingness to trade rather than to wait, demand for immediacy, depends e.g. on price volatility and diversifiability of the risk of an adverse price move.

In order-driven limit order book markets bid-ask spread is determined differently. After all, there are usually no designated market makers holding inventories to ease trading. For instance, in Helsinki Stock Exchange there are no actual market orders. Under these circumstances even the measuring the spread is not straightforward. Trades are executed automatically as prices and volumes match, which means that at the exact time of transaction bid-ask spread is zero. In order-driven markets spread can be regarded the difference between best bid and ask quotations in the limit order book at a certain time. This spread equivalent is referred to as fourchette in market microstructure literature.

On the other hand, traders can commit "market orders" by submitting an order that exactly matches an order that already exists in the order book with subject to price and quantity despite of absence of market makers. Although both the price and quantity is specified for such an order, it can be regarded as a market order, because the trade is executed instantly. In a way limit orders that are not executed immediately create the order book and supply liquidity, whereas market orders clear out limit orders and demand liquidity. (Hansson 1999: 6-7)

Theoretical analysis of Cohen et al. (1981) helps to understand, how bid-ask spreads are determined on securities markets utilizing LOB trading. The paper is based on uncertainty that submitters of limit orders have to face, as limit orders do not necessarily lead to trades. The investor is able to submit a market order at the best prevailing ask price for immediate execution, or then place a limit order. If the limit order is submitted at a price below the best prevailing bid, the probability for execution decreases, as usually on LOB markets price priority prevails in the order book and bids with a higher price will be executed first. Cohen et al. argue that there will always be a non-zero bid-ask spread. Their theory can be illustrated as follows.

Because execution via a market order is certain, while execution via a limit order is not, it never pays for the investor to submit a limit order (e.g. a bid) at a price too close to that of a counterpart limit order (e.g. an ask). As the investor considers submitting a bid closer and closer to an ask already established on the market, he becomes more and more attracted by this counterpart offer. At some point this "gravitational pull" dominates and the investor prefers choosing a market order. This causes the gap between bid and ask prices. Cohen et al.. (1981)

Still, using spread based on bid and ask quotations as a liquidity measure has been criticized. Eleswarapu (1997) & Petersen and Fiolkowski (1994) mention that comparing liquidity of different dealer markets based on quoted dealer spreads may be misleading, as liquidity investors face may also depend on possibilities to trade inside spreads using limit orders. For instance, according to Petersen and Fiolkowski specialist is involved in less than 20 % of the volume on NYSE. They also found that on NYSE effective spread, spread paid by investors in practise, is on the on the average approximately half of the posted spread quoted by the dealers. On the other hand, based on simple microeconomics trading inside the book should also impact on dealers' spreads: dealers have to compete with submitters' limit orders (Benston and Hagerman 1974, Bodie et al. 1999: 79).

Koivisto (1998: 19) points out that also on order-driven markets trading may happen outside of the book. For example, on Helsinki Stock Exchange pre-arranged negotiated trades are possible. These flaws make posted spreads only an approximate guide to current price level for transactions. For finding a more reliable evaluation of effective spread investors face in practise several quantitative methods utilizing transaction data have been developed (see e.g. Roll 1984, Glosten and Harris 1988, Hasbrouck 1993, de Jong et al. 1996).

Grossman and Miller (1988) remind that quoted bid-ask spread of dealers is not a pure cost of immediacy, as dealer may also include some order-processing costs in their spreads. From the view of investors bid-ask spread still represents costs of transacting.

In addition to spread, investors also have to consider direct transaction costs. These may consist of e.g. brokerage commissions, foreign exchange fees and transfer taxes.

2.2.3 Volume-related variables

Volume is also one of the most used liquidity measures. After all, there is no liquidity without volume. This is especially true in order-driven markets. If trading is active, it is naturally easier to find a counterparty for a trade. In dealer markets high volume also must drive drown bid-ask spreads, as dealers have to compete with limit orders submitted by other brokers and investors. This negative correlation between changes in spreads and volume is demonstrated empirically by e.g. Hansson (1995). Volume is also in connection with other liquidity measures, like amount of trades and trading frequency.

Relation between trading volume and market liquidity has been approached in many theoretical papers. Hicks (1962) has considered connection between volume and riskiness of the execution price. According to Pagano (1989), active markets can absorb large orders without notable costs of adverse price changes for investors that place such orders. Market models of Kyle (1985) and Admati & Pfleiderer (1988) suggest positive feedback between trade intensity and market liquidity. Amihud and Mendelson (1986) theoretically prove that in equilibrium liquidity should be correlated with trading frequency. As statistical liquidity measures volume-related variables may still have some deficiencies, as they do not measure transaction costs or transaction speed directly. Sufficient volume is rather a condition for a liquid market than an independent liquidity measure.

Liquidity ratio is also a widely used empirical measure in inter-market comparisons of market liquidity. It is defined as the ratio of average dollar volume of trading to the average price change during some interval. A high value for the ratio should indicate that a large block of shares were traded with little price change while a low value should mean that large blocks induce a large adverse price change. However, this measure is very harsh. At its best it tells about past average associations between price changes and volume, but does not necessarily indicate well price impact of sudden arrivals of large blocks. Naturally price changes also are dependent on other factors than liquidity. (Grossman and Miller 1988).

2.2.4 Other liquidity measures

If detailed statistics on orders submitted by traders exists, liquidity measures can further be refined. Kyle (1985) and Hasbrouck and Schwartz (1988) suggest e.g. depth, breadth and resiliency measures. In limit order book these measures can be utilized, if the whole contents of the order book is available. In other words, data covering all executed trades is not sufficient.

Depth is related to existence of many price levels close to the best bid and asked prices on both sides of the book. If limit order volume at the best bid or ask level is not sufficient for new market orders, there will be another price level at a price relatively close to the previous one to trade against. The market is not deep when price-rounding is large and spreads substantial. Hasbrouck and Schwartz (1988)

Breadth refers to the existence of limit orders in sufficient volume for the price levels near the best bid and ask prices. If market lacks breadth, large trades can not be executed without accepting notably weaker prices than the best prevailing bid and ask prices. Naturally also good depth facilitates large trades. Hasbrouck and Schwartz (1988)

Resiliency means the responsiveness of new orders to price changes caused by temporary order flow imbalances. Resiliency is high, if market adjusts quickly to errors in price discovery. According to Kyle (1985), resilient markets also adjust quickly to new information that impact on underlying intrinsic value of securities. Hasbrouck and Schwartz (1988)

3 Determinants of liquidity

In this chapter major factors impacting on market liquidity are discussed based on literature. At the end of the chapter the research hypotheses are also presented.

3.1 3-component theory of bid-ask spreads

3.1.1 Determination of spreads based on the 3-component theory of bid-ask spreads

In market microstructure theory determination of bid-ask spreads is usually approached from the view of market makers. This is natural considering that in major U.S. exchanges market makers have an important role in trading. On dealer markets quoted bid-ask spread also is a natural and easy liquidity measure, what also probably explains interest in spreads and determinants of them in market liquidity studies.

On dealer markets bid-ask spread is an compensation for dealers for providing immediacy of execution to other traders by selling and buying securities from their own inventories. Theories of determinants of spreads quoted by dealers were firstly presented by Demsetz (1968), and improved later by e.g. Bagehot (1971), Garman (1976), Stoll (1978a, 1978b), Ho and Stoll (1981), Copeland and Galai (1983), Glosten and Milgrom (1985) and Easley and O'Hara (1987). Based on the theories, magnitude of bid-ask spread is defined by three components: order-processing costs, inventory costs and adverse selection costs. Much of the current understanding concerning bid-ask spread formation process builds on these papers.

Component of order-processing costs usually refers to direct costs of running a market making business. These transaction costs may cover employees' wages and used equipment. The 3-component theory has mainly been interested in spread differences between single securities. Therefore, several papers suggest that at least part of the differences can be explained by transaction costs different securities cause. Traditionally, share price, tick size and price of a round lot are typical factors causing differences in bid-ask spreads. Tripathy and Peterson (1991) argue that stock price and percentual bid-ask spread should be negatively correlated. According to Tripathy and Peterson, this is caused by variable labour and communication costs that are positively related to transactions: if transactions are made in standard trade sizes (e.g. one hundred shares), costs per transaction and percentual spread should be smaller in highly priced shares. Glosten and Harris (1988) also suggest that tick sizes (minimum price change restriction) increase spreads of low priced shares: low priced shares have higher percentual tick sizes. Stoll (1978b) argues that for high round lot prices the minimum cost of making a transaction is spread over more dollars, and this implies a negative relation to percentual spreads.

Inventory costs are also important for dealers. Supplying immediacy to investors requires holding inventories to ease trading. However, for dealers this means moving away from desired portfolio in order to accommodate the desires of investors to buy or sell a stock in which the dealer in question specializes. As a result dealers may assume an unnecessary risk and move to a level of risk and return which may be inconsistent with personal preferences. Therefore, holding this suboptimized portfolio must be compensated in a form of spread. The greater inventory costs a security in question causes, the wider should be the spread between bid and ask quotations. Active trading decreases inventory costs, as on this case limit orders submitted by investors can be used as a substitute of inventories to facilitate trading. Holding risky shares also increases inventory costs, assuming dealers are risk averse.

Component of adverse selection costs refers to risks of asymmetric information for dealers. This perspective is first suggested by Bagehot (1971). The theory of asymmetric costs is based on information differences between traders. Informed traders trade on the basis of private information that is not known to all other traders when trade takes place. For instance, corporate insiders may have an information other investors may not have. Liquidity traders, on the other hand, trade for reasons that are not related directly to the future payoffs of traded securities – their needs arise outside the securities market. Included in this category are for instance large traders, such as some financial institutions, whose trades reflect the liquidity needs of their clients or who trade for portfolio-balancing reasons.

Bagehot (1971) suggests that uninformed dealers lose in trades conducted with traders possessing superior information. This is caused by better possibilities of informed traders to estimate future values of securities, compared to uninformed dealers or liquidity traders. Therefore, dealers have to offset the losses by gaining in transactions with liquidity traders. These gains are accomplished by setting a sufficiently large spread. Ideas of Bagehot were further improved by explicit market models of Copeland and Galai (1983), Glosten and Milgrom (1985) and Easley and O'Hara (1987). Usually dealers cannot directly identify informed traders. On the other hand, shares with certain qualities, like small size and high ownership concentration of an issuing company and small trading volume, are evaluated to be more prone to informed trading, hence increasing the spreads.

3.1.2 Suitability of the 3-component theory on LOB-markets

Considering this study, market liquidity and its movements on a small LOB-market, applications of the 3-component theory must be approached with reservations. After all, it is originally developed from the view of market makers, which do not exist e.g. on Helsinki Stock Exchange. Still, Hedvall (1994) and Hansson (1995, 1999) have shaped the 3-component theory from the view of LOB-markets and found it suitable for describing bid-ask spread formation also in this environment. Hedvall (1994: 84) points out that "the fundamental reasons for behind a costs of a market maker providing liquidity to the market are also present when liquidity is supplied in the form of limit orders".

Adverse selection costs caused by informational asymmetries between traders should impact on liquidity on LOB-markets, too. Originally the 3-component theory concentrated on asymmetries between dealers and informed traders whereas on LOB-markets informational asymmetries are probably present between the investors trading with each other. Potential informational asymmetries may make traders less inclined to trade, and uninformed ones may pursue to compensate their losses for informed investors submitting higher asks and lower bids. Therefore, informational asymmetries may also on LOB-markets explain spread differences. (Hansson 1995)

One might argue that adverse selection costs would mainly concern single shares because few traders probably possess privileged information about broad market movements, not general movements. For instance, most of the privileged information of a corporate insider is usually thought to pertain only to that specific corporation. However, there might be other types of secret information, such as revolutionary new technology that could influence many firms, not necessarily all in the same direction. In addition to corporate-specific information private macroeconomic information may also advantageous in trading. For these reasons, Chordia et al. (2000) suggest that such information may induce swings of market liquidity. According to theories by Admati and Pfleiderer (1988) and Foster and Viswanathan (1990), informed trading may also take place during certain periods, potentially causing seasonals of spreads.

Order-processing costs may also impact on LOB-markets, but not through the economies of scale of market makers. For instance, on LOB-markets small price of a round lot should allow more frequent trading, increase order flow and competition in the order book and hence decrease spreads (Hansson 1995). However, order-processing costs are chiefly used to explain differences between individual securities, not explaining swings in market liquidity. On the other hand, Chordia et al. (2001) document a notable decrease in average of bid-ask spreads of NYSE-listed securities as a result of reduction of the minimum tick size in June 1997. Still, order-processing costs –related variables do not probably explain occasional seasons of low and high liquidity as institutional factors, because they are relatively fixed.

Role of inventory costs is relatively ambiguous on LOB-markets. Hansson (1999: 16-18) regards inventory-related costs as a quite insignificant factor of bid-ask spreads on LOB-markets, mainly due to missing designated market makers. For instance, on Helsinki Stock Exchange brokerage firms are allowed to trade with customers from the firm's own inventory, but only on the approval of the customer, but since the brokers have no market-making obligations, this type of trading is probably only a small fraction of all trading. Hence costs must be covered mainly through trading commission instead of bid-ask spreads. An attempt to measure importance of each bid-ask component in a dealer market also showed that importance of inventory costs appears to be relatively small in comparison with order-processing costs and costs for asymmetric information, only about 10 % of the spread (Stoll 1989). On the other hand, Hedvall (1994: 87-88) argues that inventory costs also exist on LOB-markets, but in less explicit forms.

3.2 Association between trading volume and bid-ask spreads

Trading volume and bid-ask spreads are both liquidity measures, and should correlate negatively. This negative association realizes through several mechanisms.

Reasons for negative association between spreads and volume can be found from classical microeconomics: if markets are active, interest in trading is high and there are many traders submitting orders. Under these circumstances, investors have to compete with each other and this drives down spreads. On dealer markets, dealers have to compete with other dealers and traders posting limit orders (Bodie et al. 1999: 79). Also, as volume increases, amount of limit orders increase and this facilitates trading. Market makers can use them as a substitute of inventory: the greater the number of transactions, the lower the amount of inventories that market makers have to hold. This should decrease inventory costs and further drive down the spreads (Benston and Hagerman 1974, Stoll 1978b). On LOB-markets competition takes place between the investors posting limit orders. During active markets it is relatively easy to find a counterparty for a trade without notable spreads.

Theories of Cohen et al. (1981) also refer to negative association between spreads and volume on securities markets. During thin trading investors do not like to post limit orders to pursue better term of trade compared to current terms, as probability of execution of a limit order is low. Hence, traders will prefer submitting market orders despite the higher cost of a large spread to achieve certain execution. Therefore, on thin markets larger spreads remain, because traders are reluctant to close the gap by posting limit orders due to low probability of execution.

Trading volume is also related to asymmetric information effects. There is a lot of academic literature suggesting that private information is a very significant factor of asset prices (see e.g. Kyle 1985, French and Roll 1986, Admati and Pfleiderer 1988, Stoll and Whaley 1990, Barclay et al. 1993, Barclay and Warner 1993). According to these theories, private information possessed by some investors is revealed through trading. Under these circumstances, large trading volume should reduce informational asymmetries between traders, as every trade conveys information. For instance, Easley et al. (1996) show that the adverse selection costs should be lower for actively traded shares. Admati and Pfleiderer (1988) also suggest that during active trading there are many informed traders on the market, and their competition improves terms of trade of uninformed investors. Hence, active trading may decrease bid-ask spreads as a result of reduced asymmetric information problems.

Based on described mechanisms, spreads and trading volume should correlate negatively. Empirical findings of Hedvall (1994) and Hansson (1995) on Helsinki Stock Exchange support the suggestion: during seasons with active trading, spreads are smaller. Chordia et al. (2001) report similar findings on NYSE. Based on findings of e.g. Stoll (1978b), Laux (1993) and Hansson (1995) single shares with low trading volume have higher spreads than more actively traded shares.

However, the negative association described is necessarily not so straightforward. Firstly, active trading may also be caused by informational asymmetries that increase spreads despite of more active trading (Copeland and Galai 1983). Secondly, high trading volume may be associated with volatile prices that may increase spreads. Association between equity prices and liquidity is contemplated in the next chapter.

3.3 Equity price volatility, price trends and market liquidity

In literature price volatility and price trends are probably the most contemplated drivers of market liquidity and trading volume.

3.3.1 What moves share prices?

Academic studies discussing drivers of equity price changes are several. Determinants of short-run price changes are discussed by e.g. Beaver (1968), French and Roll (1986) and Barclay et al. (1990). Volatility differences of longer seasons and their association between macroeconomic environment are studied by e.g. Schwert (1989) and Liljeblom and Stenius (1997).

According to a very traditional perspective, prices react to new, published information. In theory, equity prices equal net present value of expected dividends (Williams 1938) or accounting earnings (Ohlson 1995). A classical paper concerning association between asset returns, trading activity and information announcements is conducted by Beaver (1968), refined later by e.g. Kim and Verrecchia (1991a, 1991b). In these theories, information is often defined as a change in expectations considering future dividends and earnings. According to another definition, change of expectations must also be sufficiently large to induce a change in the decision-makers' trading behaviour. Price changes induced by new information equal average change in investor's expectations.

A second hypothesis of asset price changes is a noise trading theory, suggested by e.g. Shiller (1981, 1986), Black (1986), French and Roll (1986) and Summers (1986). Shiller (1981) argues that the level of equity market volatility is too high relative to the ex post variability of dividends. Noise trading hypothesis assumes that process of trading introduces error noise into asset returns, causing this excess volatility. For instance, investors overreacting to each other's trades may induce price changes. Investors' overreaction to each others' trades and correction of the overreaction is suggested to cause equity serial correlation behaviour typically documented on the U.S. market: in the short run consecutive returns are positively autocorrelated and in the long run negatively autocorrelated (French and Roll 1986).

A third hypothesis of asset price changes concerns private information: according to models of e.g. Kyle (1985), Black (1986), French and Roll (1986), Admati and Pfleiderer (1988) and Foster and Viswanathan (1990) price changes are triggered by private information of some investors through trading.

Naturally, it is very difficult to filter impact of each of the described mechanisms on asset price changes, and probably all of them have some kind of a role. However, some empirical papers argue that impact of private information as a price driver is relatively notable on equity markets (see e.g. French & Roll 1986, Stoll and Whaley 1990, Barclay et al. 1993, Barclay and Warner 1993). For instance, French and Roll pursue to find why stock returns are much more volatile during exchange trading hours than non-trading hours. According to their models, approximately only 4% to 12% of daily variance can be explained by noise trading. Therefore, French and Roll argue that most of the difference between volatility of trading and non-trading hours is caused by differences in flow of information. However, French and Roll reason that most of this information must be private, because return variances over exchange holidays on working days are notably smaller than variances over trading days. This argument is based on assumption that flow of public information should be equal during exchange holidays and other working days.

Explanatory power of fundamentals also seems quite low based on papers of e.g. Roll (1988), Cutler et al. (1989) and Schwert (1989). Roll (1988) finds that approximately only one third of the monthly variation in individual stock return can be explained by systematic economic influences. Cutler et al. (1989) document that macroeconomic news can explain only one-third of the movements of a stock market index. This further strengthens the view that public information only partly explains equity return volatility.

Additionally, equity market volatility has noted to change over time. For instance, estimates of the standard deviation of monthly U.S. stock returns vary from two percent to twenty percent per month during the 1857-1987 period (Schwert 1989). Liljeblom and Stenius (1997) report volatility changes of Finnish equity market during the 1920-1991. Schwert and Liljeblom and Stenius pursue to find different explanatory variables for these volatility changes, mainly using macroeconomic variables. Their theoretical motivation for such a link is based on a simple discounted present value model for a share price. Using the model, volatility of share prices depends on volatility of expected future cash flows and future discount rates, and covariances between them. Since these factors depend on macroeconomic cycles, it is plausible that a change in the level of uncertainty about future macroeconomic conditions would induce a change is equity market volatility. Mainly used explanatory variables for equity market volatility changes include industrial production, measures of corporate profitability and leverage, interest rates, inflation and monetary growth. Schwert finds that share market volatility is clearly higher during recessions and suggests that this is induced by increased financial leverage of companies. Also interest rates, inflation and monetary growth volatility seem to correlate with share market volatility. Still, Schwert was able to explain only 2.2% - 5% of the monthly variation of the share market data with these variables. However, Liljeblom and Stenius (1997) found a notably stronger link between share market and macroeconomic volatility.

3.3.2 Association between return volatility and bid-ask spreads

Based on theoretical literature and many empirical findings, equity volatility and bid-ask spreads should have a positive association, i.e. volatility increases raise spreads.

Based on several empirical findings, volatile shares have ceteris paribus wider spreads than less volatile shares. This link is documented by e.g. Benston and Hagerman (1974), Stoll (1978b) and Laux (1993) on U.S. market and by Hansson (1995) on Finnish market. For instance, according to multivariate calculations of Stoll (1978b) and Hansson (1995) increase of 1% in volatility of a single share raises bid-ask spread approximately by 0.10%.

Traditionally, the positive association has been explained by inventory costs on dealer markets. Holding an inventory of volatile shares induces a higher risk, and dealers compensate this risk with wider spreads.

Additionally, high volatility has also traditionally been connected with high adverse selection costs (see e.g. Copeland and Galai 1983). This connection builds on above described theory of private information as a driver of price changes. In this case, high volatility is a result of private information revealed in trading, and this raises adverse selection costs and spreads.

Hansson (1995) suggests that on LOB-markets volatility does not likely impact on spreads through inventory costs, but through uncertainty of an execution of a trade in a limit order book. Informed investors are probably better informed about optimal limit order prices than uninformed, and this advantage becomes emphasized during volatile prices. This induces uninformed investors to avoid losses to informed ones by submitting higher asks and lower bids, thus widening spreads. More volatile shares are, more imminent is the problem of limit orders being bagged by better informed investors. Hedvall (1994: 87-88) argues that impact of high volatility on spreads through inventory costs may also be important in LOB-markets. For instance, brokers trying to find a second participant for in-house trades have probably more difficulties during volatile prices.

Chordia et al. (2001) also suggest that high price volatility increases spreads through increased uncertainty that reduces liquidity on equity markets. Under these circumstances, investors may be less inclined to trade and engage in short-term speculating. However, Chordia et al. were not able to find empirical evidence for their hypothesis: actually, daily variation of market-wide spreads (arithmetic average of spreads of single shares) had a negative connection with recent equity market volatility. On LOB-markets sharp price prices could be related to unsymmetric order book structure, where majority of investors post bids or asks. This may have different consequences for market liquidity (Hedvall et al. 1995).

Based on literature findings, volatility and bid-ask spreads should therefore ceteris paribus have a positive association. However, active trading is often noted to be connected with high volatility. This mechanism can reduce spreads despite of higher volatility. Association between trading activity and price changes is discussed in the next chapter.

3.3.3 Association between trading volume and price changes

Association between trading volume and price changes on securities markets is a relatively widely studied issue. In addition to interest in explaining empirical phenomena of financial markets, understanding price-volume relation is important as it provides insight into the market structure: in several theoretical market models, price changes and trading have a certain connection.

There is an old Wall Street saying that "it takes volume to make prices move". Even though mentioned causality is difficult to verify, numerous empirical findings support this positive relation between price changes and volume. A comprehensive analysis of the research on the issue is conducted by Karpoff (1987). Positive correlation between absolute price changes and volume has been documented on several securities markets, including equity, futures and bond markets, using both the single securities and market indices. This relation also usually seem to apply using both short and long differencing intervals, i.e. absolute price changes over single transactions, hours, days, weeks, months and even years appear to be positively correlated with trading volume. Similarly, correlation between price volatility measured e.g. as variance of stock returns and trading volume have noted to be positive. In addition to described contemporaneous relation, several papers have approached the issue utilizing Granger causality tests to examine if recent stock price movements are caused by recent changes in trading volume and vice versa (see e.g. Rogalski 1978, Smirlock and Starks 1988 and Hiemstra and Jones 1994). However, in many analyses correlation appears to be relatively weak (Karpoff 1987).

On Finnish equity market relation between return volatility has been researched by Bergholm and Liljeblom (1990), Martikainen et al. (1994) and Liljeblom and Stenius (1997). Bergholm and Liljeblom compared two seasons differing in term of trading volume, and found that season of more active trading was characterized by higher volatility. On the contrary, according to regression model of Liljeblom and Stenius covering years 1925-1991 there might be negative relation between trading volume and return volatility.

There are several explanations for the phenomenon. Beaver (1968), Pfleiderer (1984), and Holthausen and Verrecchia (1990) suggest that trading volume arises due to differences across investors in interpreting public information announcements. New information causes a lack of consensus regarding asset prices, as single investors interpret its importance for security prices differently. This boosts trading, as investors pursue to utilize these new price estimates in trading. Hence, volume reflects sum of changes in the expectations of individual investors. If this new information also is significant enough to change market prices, due to this increased information flow volume and absolute price changes are positively associated (Schwert 1989). The model of Epps and Epps (1976) also explains positive association between volume and price variability with that an increase in the extent to which traders disagree is associated with larger price changes and volume. The greater the degree of disagreement among the traders, the larger the level of trading volume. According to the theoretical model of Clark (1973), daily price change is a sum of a random number of within-day price changes and variance of daily price changes is a random number of with a mean proportional to the mean number of daily transactions. Clark argues that trading volume is positively related to the number of within-day transactions, and so daily trading volume is positively related to the variability of price change. In the sequential arrival of information model of Copeland (1976, 1977) information is disseminated to only one trader at a time and that implies a positive correlation between price changes and volume. Black (1986) assumes that during seasons with high trading volume market prices are more volatile, as noise traders boosting market volatility are more active. Schwert (1989) suggests that if there is short-term price pressure due to illiquidity or inelastic equity demand curves, large trading volume being mainly either buy or sell orders may cause price movements.

However, in the long run association between trading volume and price volatility is also suggested to be negative. According to models of Cohen et al. (1978), Garbade and Silber (1979), Tauchen and Pitts (1983) and Pagano (1989) reduction in volatility of returns is caused by increased number of traders that usually accompany an increase in trading volume. If amount of traders is high, idiosyncratic demand shifts for individual investors cancel out to a larger extent. Empirical support for the argument is presented by Cohen et al. (1976), who compare New York Stock Exchange, American Stock Exchange, Tokyo Stock Exchange and Rio de Janeiro Stock Exchange. Ranking of the exchanges in terms of turnover turned out to be exactly opposite to ranking in terms of average volatility of shares in their sample. However, Tauchen and Pitts (1983) argue that this mechanism applies mainly in the long run, whereas the previously mentioned positive price-volume relation is usually observed over shorter intervals. Further, Cohen et al. (2001) suggest that recent volatility increases in equity prices increases investors' uncertainty and leads to more cautious trading, finding also empirical evidence for their suggestion. Based on the presented literature, on the whole connection between trading volume and price changes seem to be at least partly dependent on used data, data frequency and used methodology.

Additionally, potential causal relation between price changes and trading volume can be explained by traders, who utilize past price trends in investment decisions. For instance, Shiller (1986), DeLong et al. (1990) and Jegadeesh and Titman (1993) suggest that some investors utilize momentum strategy in their trading, i.e. buy shares during rising prices and sell during falling prices. These positive-feedback investment strategies build on assumption that during the investment period returns autocorrelate positively. On the other hand, DeBondt and Thaler (1985) and Lakonishok et al. (1994) document just the opposite strategy: according to contrarian strategy, shares that have performed best underperform the rest of the market in following periods. Chordia et al. (2001) further also suggest that different tools used by technical analysts may also lead to interdependence of volume, market liquidity and past price trends. Use of these different trading strategies building on past price changes may well explain increased interest in trading during aggressive price changes.

Another familiar Wall Street saying is that trading volume is relatively heavy in bull markets and light in bear markets. Many empirical papers support the hypothesis. For instance, based on equity and bond market data Epps (1975, 1977) found that ratio of volume and price change is greater for transactions in which a price ticks up than for transactions on downsticks. This also applied to measurements over daily intervals. Positive correlation between price change per se and trading volume is also documented by e.g. Rogalski (1978), Harris (1986), Richardson et al. (1987), Jain and Joh (1988) on the U.S. market and Martikainen et al. (1994) on Finnish market. Positive relation also appears to apply over several differencing intervals, from transaction level to yearly measurements. However, there are several empirical papers inconsistent with a positive correlation (Karpoff 1987). Additionally, statistically many results are quite weak. For example, in analysis of Rogalski (1978) average correlation coefficient among the stock data was 0.395.

Several researchers have attempted to explain, why trading is heavier during bull markets. Morgan (1976) suggests that volume is associated with systematic risk, and through this to stock returns. In a model of Epps (1975) volume on transactions in which price changes are positive is greater than for negative price changes. Epps assumes two groups of investors – optimistic "bulls" and pessimistic "bears". "Bulls" react only to positive information and "bears" to negative information. In this model a transaction demand curve consists only of the demand prices of "bulls", while "bears" form a transaction supply curve. Epps demonstrates that the relative optimism of the "bulls", combined with appropriate assumptions about investors' utility function, leads to that the market demand curve is steeper than the supply curve. Further, this causes that volume during positive price changes (increase in bulls' demand) is greater than volume during negative price changes (decrease in bears' demand). A model of Jennings et al. (1981) assumes that short positions are possible, but more costly than long positions. This implies that quantity demanded of an investor with a short position is less responsive to price changes than the quantity demanded by of an investor with a long position. Further, Jennings et al. show that for many cases the volume caused by a previously uninformed investor that interprets the news pessimistically is less than when the trader is optimistic. Because price decreases as a result of sales of pessimists and increases as a result of buys of optimists, Jennings et al. argue that volume is relatively high when prices increase and vice versa. Similar theory building on costly short sales is also presented by Karpoff (1988). This theory is also supported by futures markets information, in which the costs of assuming short and long positions are symmetric and the correlation between volume and returns is not significant. Finnish market has also suffered from short selling restrictions, so that this theory is important from the viewpoint of this study (Puttonen 1993).

Much more simply high volume of bull markets can be explained by assuming that in bull markets investors conceive risks are smaller than on bear markets, what further decreases risk premia. This may increase speculative trading. Investors may also be more prone to buy shares in bull markets if most of them use momentum trading strategies. Then rising share prices tempt investors to transfer their assets from e.g. bond markets to stock markets. This further increases trading volume. For instance, Grinblatt and Keloharju (2001) report that foreign investors, who hold a considerable share of Finnish equity capital, tend to follow momentum strategies on Finnish market. Based on findings of behavioural finance, investors' propensity of sell may also rise in bull markets. Investors are noted to be reluctant to realize their losses and prone to sell winning investments quite soon (Odean 1998). Hence, according to these psychological frames bear markets should be less active, as shareholders would not like to realize potential losses, but also because of there is a lower amount of well-performing recent investments to sell.

3.4 Seasonality in market liquidity

Seasonality in stock returns is one of the most commonly reported anomalies in finance. Rozeff and Kinney (1976) report seasonal patterns in an equally weighted index of NYSE price indices. According to their findings, January returns are higher than returns in any other month. Several researchers assume that this is due to tax-loss selling at the end of year, when many investors are assumed to sell shares that have declined during the previous months to realize their capital losses before the end of tax year. However, the empirical evidence of the tax-loss hypothesis is relatively mixed (Draper and Paydyal 1997). Similarly, Fama (1965) and Cross (1973) report that stock returns are abnormally high in Fridays and low on Mondays. Explanations for the phenomenon include i.e. nonsynchronous trading, spreads, specialist activity, shifts in risk and connection to other anomalies (see e.g. Gibbons and Hess 1981, Keim and Stambaugh 1984, Rogalski 1984, Miller 1988 and Ziemba 1994). In addition to the US markets, these phenomena have also been reported on other markets, including Finland (Kauppi & Martikainen 1994).

Similar seasonality has also been noted in liquidity attributes. Model of Foster and Viswanathan (1990) predicts liquidity differences between weekdays. The model analyzes interday trading where an informed trader and several liquidity traders act strategically. In the model the informed trader receives information each day, but this information becomes less valuable through time, because there is a public announcement of some portion of the private information every day. Due to this, liquidity traders have incentives to delay their transactions, if they believe that the informed trader is especially well-informed. If liquidity traders wait, they can learn from the trades that occur. This delay-tactic of liquidity traders leaves less liquidity on the market. On the other hand, the informed trader, knowing that there is a forthcoming public announcement decreasing the value of his private information, trades more aggressively and so more information is released through trading. Foster and Viswanathan assume that over a weekend accumulates more private information than on a week night and there is no equivalent increase in public announcements. Hence, they predict that trading volume should be lower and trading costs higher during Mondays than other weekdays, as liquidity traders postpone their trades due to asymmetric information. Foster and Viswanathan also document empirical evidence for their theory based on U.S. stock market data (1993). On the other hand, Chordia et al. (2001) report that Fridays are days of low trading volume and liquidity on the U.S market. Chordia et al. suggest that some behavioural reasons, like fluctuations in investor mood near weekends or sentiment over the week are behind the phenomenon. On Finnish equity market Pursiainen (1998) reports that trading volumes are lower on Mondays.

Liquidity has also been noted to have monthly patterns. Lakonishok and Smidt (1984) find very active trading volume toward the end of year on NYSE and AMEX, especially for smaller stocks. They also report that volume on the last trading day of the year is unusually high. Lakonishok and Smidt suggest that tax-related trading motives explain this. Fortin et al. (1989) report seasonality in bid-ask spreads on Nasdaq. According to their findings, spreads tend to increase persistently during all the calendar year for all but the smallest firms. Spreads tend to peak in mid- to late December and then decline during the remainder of the month and January. Also, Fortin et al. report a noticeable decline in spreads on the last December trading day. This is consistent with Lakonishok and Smith (1984), who document high trading volume during the same day. Findings of Clarke et al. (1993) based on NYSE shares are also similar. Draper and Paudyal (1997) document that spreads are the lowest during April and reach a peak at the end of December on the U.K market. Trading volume of institutional investors increases in January, whereas individual investors trade actively during March and slightly during April. Interestingly, in the U.K. end of tax-year of individual investors is April 5th, what may explain unusual liquidity changes during March/April.

Chordia et al. (2001) suggest that also holidays may impact on trading activity, due to behavioural reasons of investors. According to their results, trading activity slows down significantly around major holidays.

In addition to certain calendar dates, also certain information announcements on certain days may induce changes in market liquidity. As noted above, new information should cause disagreement between investors on security prices and this induces them to trade according to their new price estimates. Liquidity may also increase prior to announcements, if investors pursue to speculate with the impact of forthcoming announcement. Also, some privately informed traders may pursue to benefit from their private knowledge, before public announcement makes it useless (Chordia et al. 2001). On a level of individual securities earnings announcements are probably one of the most important new information sources. Tendency of earnings announcements to increase trading volume is reported by e.g. Beaver (1968) and Bamber (1986) based on the U.S. data. Empirical evidence on ability of announcements of macroeconomic information, e.g. money supply, consumer price indices or GDP figures, is controversy. According to Jain (1988), trading volume is not impacted significantly by macroeconomic announcements, whereas Chordia et al. (2001) report opposite results.

3.5 Interest rates, exchange rates and market liquidity

Interest and exchange rates have traditionally been good explanatory or predictive variables of stock returns (see. e.g. Fama and Schwert 1977, Ferson 1989 or Shanken 1990 for connection between interest rates and stock returns and Dumas and Solnik 1995, Bekaert and Harvey 1995 or Vaihekoski 1997b for connection between exchange rates and stock returns). Hence, these variables may also explain swings in stock market liquidity.

Chordia et al. (2001) pursue to clarify connection between equity market liquidity and interest rates. They predict that decrease in short-term market rates increases trading volume and decreases bid-ask spreads by lowering costs of margin trading. Lower opportunity costs of equity trading may also tempt to more active short-term trading, if interest rates are low. Empirical findings also support the hypothesis on daily level. Chordia et al. also suggest that increase in bond yields would impact on market liquidity. They suggest that increase in bond rates could cause investors to reallocate wealth between equity and debt instruments. However, a decrease could in principle impact similarly as well. Uniform impact of both short-term and bond-rates would not be surprising, considering that they are often positively correlated (Tarkka 1993: 139). In addition to mere interest rates also term spread, difference between long- and short-term interest rates is documented to predict future economic growth, stock and bond returns and inflation (Campbell 1987, Estrella and Hardouvelis 1991, Vaihekoski 1997b). Chordia et al. find that increasing term spreads reduce stock trading volume and raise bid-ask spreads on daily level.

Turnover of fixed-income markets may also be one potential determinant of market liquidity. If turnover of fixed-income markets increases notably for some reason, e.g. due to some new information chiefly impacting on fixed-income markets, this may simultaneously mean decreased interest in equity markets. In this case investors would be more interested in trading bonds of different maturities and default risk levels instead of different shares. For instance, if most of the investors expect falling equity prices or worse equity returns compared to fixed-income investments, they may pursue to find the most profitable investments among bonds. In this case, investors' mild interest in stock-picking may decrease liquidity. On the other hand, trading activity of both stock and fixed-income markets might as well correlate positively, e.g. due to some interesting macroeconomic information changing notably future estimates of investors on both the stock and fixed-income markets.

For countries dependent on foreign trade and capital exchange rates are important economic variables. It strongly impacts on industry competitiveness and financial markets. Economic history knows many cases, when trust of foreign investors has diminished and they have transferred their assets to other countries. For instance, the Asian financial crisis at the end of the 1990's was characterized by outflow of foreign capital and sharp declines of exchange rates (Krugman and Obstfeld 2000: 704-705). Absence of major foreign investors may also strongly impact on market liquidity. Pursiainen (1999) documents that absence of U.S.

investors due to U.S. holidays or non-overlapping trading times of NYSE and Helsinki Stock Exchange leads to lower trading volume on Finnish market. The result is logical, as foreign investors hold a considerable share of Finnish equities. However, link from exchange rates to market liquidity is relatively hard to derive. For instance, declines in exchange rates may reflect investors' distrust and reduced propensity to add their holdings in a country in question. On the other hand, devaluating currency may also mean better industry competitiveness and cheaper shares for foreign investors. Causation may also as well reverse, if foreign equity investors are an important factor on exchange market: in this case position changes of foreign investors would change exchange rates.

In addition to level of interest and exchange rates, also volatility in them may impact on market liquidity. On general, high volatility in both of the rates reflects uncertainty in the interest and exchange rate markets and increased risks. As the both are also important drivers of security prices, this volatility should also reflect to security prices. Dixit and Pindyck (1994) argue that increased uncertainty in future interest rates may postpone investment decisions, as it increases value of waiting. This could lead to thinner trading and lower liquidity on equity markets. Also, utilizing the real options approach they show that different sources of uncertainty are more important on investment decisions than overall level of the variables. On the other hand, high uncertainty on interest and exchange rate markets and investors' disagreement may also lead to increased trading if investors pursue to trade according to their constantly changing new estimates driven by aggressively varying interests and exchange rates. This would be consistent with the observed positive association between share price volatility and trading volume.

3.6 Other drivers of market liquidity

As bid-ask spreads and their determination are a relatively widely studied issue in market microstructure literature, many structural factors explaining spread differences between stocks have been suggested. If these structural factors change similarly in several companies, they may also induce changes of market-level liquidity. However, these structural factors do not probably explain daily, weekly or monthly variation of market liquidity, but their impact in the long run may be notable.

3.6.1 Dealer competition and bid-ask spreads

Several studies on determinants of spreads have paid attention to competition between dealers (e.g. Stoll 1978b). Strong competition between dealers should lead to lower dealer margins, i.e. smaller spreads and vice versa. Empirical evidence generally supports the hypothesis that competition decrease spreads on dealer markets.

However, competition between dealers is not as straightforward issue on LOB-markets. All brokers can trade all shares, and there are no designated market makers. However, Hedvall (1994: 88-89) and Hansson (1995) suggest that members of the exchange may specialize in some certain shares. Due to this specialization, some members may activately act as dealers for some certain shares and may therefore have achieved a role close to a market maker's. If some shares are mainly traded by a few brokers, Hedvall and Hansson suggest that brokers' position is relatively similar to a specialist's and that they may exercise some monopoly power in setting prices. This strong position also give brokers notable information advantage against other brokers, and resulting informational asymmetries may widen the spread. Hansson documents that investors tend to trade shares with a strong broker market concentration outside of limit order book and prefer prearranged trades.

In addition to intramarket competition between dealers on the same market, similar competition should also take place between different markets and decrease spreads, if a certain share is listed on several markets (Wood and McInish 1992). On the other hand, Amihud and Mendelson (1995) argue that multimarket trading may also increase spreads: splitting orders across different markets may decrease liquidity, because it may fragment order flow and weaken the price discovery process. Hansson (1995) and Pursiainen (1999) have studied dependence of bid-ask spreads and multimarket listings, but their results are relatively mixed.

3.6.2 Company characteristics and bid-ask spreads

Hedvall (1994: 90-92) and Hansson (1995) predict that ownership concentration and firm size may impact on spreads.

If the ownership of a company is widely dispersed among a large number of shareholders, each lacking the control of the company, the difference between insider and outsider owners is small. On the other hand, if power in the firm is concentrated in the hands of a few major shareholders, difference is larger. In this case adverse selection costs and therefore also spreads should be higher, as corporate insiders may have information advantages. Also, if holdings are concentrated to a small number of large investors, liquidity may suffer if they keep their shares as a long-term investment and a reluctant to trade. Then finding counterparties for trades may be relatively difficult. On the other hand, if holdings are concentrated to e.g. institutional investors trading more frequently than small investors, trading volume and liquidity may even improve.

Firm size may also impact on adverse selection costs. Smaller companies are usually less followed by analysts, and information available is small compared to bigger companies. Also information impacting on prices of smaller companies is usually firm-specific and less frequently released than information affecting prices of large firms, which often tend to be macroeconomic. For these reasons, Hedvall and Hansson (1994) suggest that problems related to asymmetric information are more severe with small firms with high ownership concentration, and this may increase spreads. However, empirical tests of Hansson do not ceteris paribus support the hypothesis.

3.7 Research hypotheses

The previous literature study suggests that several potential factors describing macroeconomic conditions and stock market performance may explain movements of market liquidity. Based on literature findings and a priori reasoning the following hypotheses concerning association between market liquidity, trading activity and explaining variables on Helsinki Stock Exchange are made. In this section the hypotheses are presented briefly. The literature study above provides more detailed clarification of background of the hypotheses and empirical research of them.

H1: Bid-ask spreads and trading volume have a negative association

As both of the measures are liquidity measures, they should yield consistent empirical results. In this case spreads should decrease, as trading activity increases and increased competition between investors drives down spreads. The hypothesis is consistent with earlier findings of e.g. Hedvall (1994) and Hansson (1995), who report that bid-ask spreads are low during seasons characterized by high volume on Finnish equity market. Based on e.g. Chordia et al. (2001), on the U.S. market the mentioned negative relationship also holds.

H2: Equity return volatility has a negative association between bid-ask spreads and positive association between trading volume

I expect that during volatile prices liquidity is higher. Based on most of the existing theoretical literature, this relationship builds on connection between information and prices: during volatile prices there is a lot of new information on the market and investors disagree on intrinsic prices. This is connected with active trading. The hypothesis is consistent with most of the empirical research concerning volume-volatility relationship (see e.g. Karpoff 1987 and Chordia et al. 2001). Finnish evidence concerning this price-volume relationship is mixed (see e.g. Bergholm and Liljeblom 1990 and Liljeblom and Stenius 1997). I expect that this active trading during volatile prices also drives down spreads, even if individual share volatility is noted to be cross-sectionally associated with higher spreads (Hansson 1995).

H3: Equity returns have a negative association between bid-ask spreads and positive association between trading volume

Based on most of the empirical research conducted, trading should be more active on bull market (Karpoff 1987). Martikainen et al. (1994) also report this connection to hold on Finnish market over daily intervals. There are many explanations for the phenomenon, ranging from costly short selling (Jennings et al. 1981) to different aspects of market psychology (Odean 1998). Active trading should also decrease spreads.

H4: Bid-ask spreads and trading volume are seasonal

Based on international studies (see e.g. Draper and Paudyal 1997) bid-ask spreads and trading volume have seasonal patterns. As Finnish equity returns are seasonal consistent with international findings (Kauppi and Martikainen 1994), I expect that this also applies to spreads and trading volume. After all, both of the phenomena may have partly similar background drivers (Lakonishok and Smidt 1984). I expect that tax-loss selling explains monthly seasonalities and seasonalities in asymmetric information (Foster and Viswanathan 1990) differences between weekdays. Consistent with earlier empirical evidence, U.S.

holidays indicating potential absence of U.S investors should decrease trading activity (Pursiainen 1998) and hence increase spreads. Like on the U.S. market, closeness of major holidays should decrease liquidity based on behavioural reasons also in Finland (Chordia et al. 2001).

H5: Trading volume of bond markets has a positive association between bid-ask spreads and negative association between trading volume

I assume that increased interest in bond trading characterized by high trading induced by e.g. market sentiment or interesting bond market –related news simultaneously decreases interest in equity trading, hence decreasing trading volume and increasing spreads. The hypothesis has no background in existing literature.

H6: Interest and exchange rate volatility has a positive association between bid-ask spreads and negative association between trading volume

Based on theoretical models of Dixit and Pindyck (1994) increased uncertainty in future interest rates may postpone investment decisions, as it increases value of waiting. Similarly, exchange rate volatility may also make investors more cautious. This should decrease trading volume and increase spreads.

H7: Interest rates have a positive association between bid-ask spreads and negative association between trading volume

High interest rates mean high opportunity costs and increased costs of margin trading for equity investors. This should decrease interest in trading, weaken trading activity and increase spreads. The hypothesis is consistent with empirical findings of Chordia et al. (2001) on the U.S. market.

H8: Appreciating Finnish exchange rate decreases bid-ask spreads and increases trading volume

I expect that Finnish exchange rate appreciation is related to foreign investors' tendency to increase their positions in Finnish stocks that are widely in foreign ownership. This induces positive equity returns and increased liquidity, according to the hypothesis 2. The hypothesis has no background in existing literature.

4 Methodology and data

In this chapter research methodology and data are presented. First, used quantitative methods and their suitability for the study are discussed. Second, Helsinki Stock Exchange and formation of research variables are introduced.

4.1 Used quantitative methods

4.1.1 Multiple regression method

In this study association between market liquidity attributes and explaining variables is studied with multiple regression. Multiple regression is a simple, but powerful method that is very widely utilized in business and economics. Both the cross-section and time-series data can be analyzed with multiple regression equations. In study similar to this one Chordia et al. (2001) explain time-series variance of liquidity attributes with explaining variables using multiple regression method. (Pindyck and Rubinfield 1997:1)

Regression analysis is concerned with the study of the relation between one variable called the explained, or dependent, variable and one or more other variables called independent, or explanatory variables. Based on statistical data can be formed a linear model (Equation 1.), which predicts value of dependent variable y based on independent variables $x_1 - x_k$. In addition to numeral dependent variables also qualitative dummy variables can be used. Factor β_0 is a constant intercept term and factors β_1 - β_k are coefficients. They are calculated by fitting the model to the statistical data as well as possible. Error term, in other words residual, ε_i describes the difference between prediction calculated by the regression model and real value of y_i. (Gujarati 1992: 117 -118).

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ki} + \varepsilon_i \qquad (1.)$$

In this study "goodness" and statistical significance of regression models are evaluated with traditional R^2-statistic and F-tests. Significance of single coefficients and predictions is approximated with t-tests. (Gujarati 1992: 194-206).

Based on findings of e.g. Bergholm et al. (1990) and Hansson (1995) seasons of different volume may have notable impact on different stock market qualities. Bergholm documents that volume changes are connected with i.e. stock return distributions, and Hansson finds that determinants of spreads of different securities depend on market volume. Therefore, I also want to test, if the regression model is similar during low and high turnover periods. Statistically this can be conducted with Chow test. In Chow test, identity of two different regressions is clarified. Regressions 2a. and 2b. are identical, if $\alpha_1 = \beta_1$, $\alpha_2 = \beta_2, \ldots, \alpha_k = \beta_k$ and $\text{Var}(\varepsilon_i) = \text{Var}(\varepsilon_j)$.

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ki} + \varepsilon_i \tag{2a.}$$

$$y_j = \alpha_0 + \alpha_1 x_{j1} + \alpha_2 x_{j2} + \ldots + \alpha_k x_{kj} + \varepsilon_j \tag{2b.}$$

In Chow test models are first regressed separately for the both data sets (from observations 1 to N and 1 to M), and sum of squared residuals are calculated. Sum of the squared residuals of the both regressions equals unrestricted sum of squares (ESS_{UR}). Second, one regression is formed for the one whole data set from observation 1 to observation N + M for calculating restricted sum of squares (ESS_R). Test statistic (Equation 3.) follows F distribution with k and N + M – 2k degrees of freedom, and based on it null hypothesis of identical regression parametres can be either accepted or rejected. (Chow 1960)

$$F_{k,\,N+M-k} = \frac{(ESS_R - ESS_{UR})/k}{ESS_{UR}/(N+M-k)} \tag{3.}$$

4.1.2 Econometric problems of multiple regression method

Despite of several advantages provided by multiple regression method, it also brings forth some potential econometric problems. Fitting a regression model is usually conducted with a method of ordinary least squares (OLS). According to OLS method the "line of best fit" is said to be that which minimizes the sum of the squared deviations of the points of the graph from the points of the straight line. OLS method is convenient, as it easily permits versatile testing of statistical significance (Pindyck and Rubinfield 1997: 3-7).

Potential econometric problems stem from certain qualities that linear regression methodology demands from the used data. Specifically, the model described in Equation 1. requires the following qualities (Gujarati 1992: 144-147):

1. Independent variables are nonstochastic
2. The error term has a zero mean value
3. Homoscedasticity, i.e. the variance of the error term is constant
4. No autocorrelation, i.e. error terms corresponding to different observations are independent and therefore uncorrelated
5. No multicollinearity, i.e. independent variables do not have a linear relation
6. Error term follows normal distribution

Violation of the assumptions may lead to spurious results. Time-series data is usually especially sensitive to problems related to autocorrelation, as errors associated with observations in a given time period may easily carry over into future periods (Pindyck and Rubinfield 1997: 159). Time-series data of financial markets may also suffer from heteroscedasticity (Schwert and Seguin 1990. Potential problems with multicollinearity are always present if several independent variables are used, especially if they measure similar factors.

In addition to visual inspection of residual plots there are several formal ways to test, if the used regression model suffers from the mentioned flaws. In this study probably the most popular way for detecting autocorrelation, Durbin-Watson test, is utilized (Durbin and Watson 1951). Popularity is probably due to its simplicity, as Durbin-Watson d –test statistic is easy to calculate based on regression residuals of observations from 1 to T. For testing potential heteroscedasticity of the regression model White test (White 1980) is used. White test builds on regressing each residual of the original regression model on independent variables and detecting statistical significance of the new model. Existence of serious multicollinearity in the regression model can be concluded based on high pairwise correlation coefficients between independent variables or a combination of high R^2 measure and low t-ratios (Gujarati 1990: 298-303).

$$d = \frac{\sum_{t=2}^{T} (\varepsilon_t - \varepsilon_{t-1})^2}{\sum_{t=1}^{T} \varepsilon_t^2} \tag{4.}$$

Regression data that suffers from autocorrelation can be fixed by the method of generalized least squares (GLS). GLS methodology transforms the original data so that in the transformed model residuals do not autocorrelate. (Gujarati 1990: 365-372).

GLS correction for autocorrelation is based on assumption, that dependence between consecutive residuals follows some certain formula. The most usual case is first-order autoregressive error process, AR(1) (Formula 5.). AR(1) error process is generated by a rule that says the residual in time period t depends on residual in the previous period and a random variable ν.

$$\varepsilon_t = \rho \varepsilon_{t-1} + v_t \qquad 0 \leq |\rho| < 1 \tag{5.}$$

Based on AR(1) correction dependent and independent variables of the original model (Formula 1.) are transformed by reducing the previous observation multiplied by ρ from each of the observations. If residuals of the original OLS-based regression model follow AR(1) process, it can be shown that model based on new transformed variables has independently distributed residuals. Thus, OLS regression applied to transformed variables yields efficient estimates of all the regression parameters. Transformation of the variables can also be utilized, if stochastic process between residuals is more complicated. The described GLS correction can also be extended to residuals that follow autoregressive process of order more than one. GLS can also be applied to heteroscedastic residuals. (Pindyck and Rubinfield 1997: 160-163).

Using GLS in empirical studies demands knowledge of the statistical process between residuals, or in case of AR(1) type error process the value of ρ. Several procedures are developed to produce estimates of ρ. By making several approximations, it is possible to show that d statistic of Durbin-Watson test equals 2(1-ρ). Thus, ρ can be calculated based on d-statistic. Calculating a regression model between consecutive residuals can also be used to produce estimates for ρ. This method is especially useful, if residuals follow autoregressive process more complicated than AR(1). In this study, regression models suffering from autocorrelation have first been corrected using AR(1) utilizing ρ calculated from Durbin-Watson test. If this correction does not seem to correct autocorrelation based on Durbin-Watson test, more complicated autoregressive error processes are utilized. In these cases, models are estimated based on regression between residuals (Pindyck and Rubinfield 1997: 163-166).

Additionally, time-series regression models also demand stationarity from the used data, as regressing non-stationary time series on each other may lead to spurious results. The time-series is stationary, if the stochastic process that generated the series is invariant with respect to time. Econometric texts often recommend using changes in values instead of absolute values with correlation and regression analysis tools, because absolute values may lead to spurious results. This is due to fact that many economic time-series behave like random walks, i.e. they are generated by a non-stationary random walk process, which can be transformed to a stationary one by differencing it once. Therefore, in this study mainly changes in variables are used. Used time series are tested with a unit root test developed by Dickey and Fuller for increasing robustness of regression models (1979, 1981). (Pindyck & Rubinfield 1997: 507-513)

4.1.3 Descriptive statistics

In addition to regression results, typical descriptive statistics are also reported. These include mean, standard deviations, autocorrelation coefficients, skewness and excess curtosis measures of liquidity and trading activity attributes and correlations coefficients of explanatory variables.

Autocorrelation analysis tells, how much correlation there is between neighbouring data points in one time series $y_t = y_{1,\ldots,} y_T$. Sample autocorrelation coefficient p_k can be calculated with different lags k (Equation 6.). Statistical significance of single coefficients is tested utilizing Bartlett test (1946). Bartlett test builds on the fact that sample autocorrelation coefficients of white noise process having no autocorrelation are normally distributed with mean 0 and standard deviation of $1/\sqrt{T}$.

$$p_k = \frac{\sum_{t=1}^{T-k}(y_t - \bar{y})(y_{t+k} - \bar{y})}{\sum_{t=1}^{T}(y_t - \bar{y})^2} \tag{6.}$$

Symmetry of distributions is described by skewness and kurtosis. Skewness S is a statistic that provides useful information about the symmetry of a distribution consisting of observations $y_1, \ldots, y_T$ (Equation 3.). S is zero for all symmetric distributions, including the normal. Excess kurtosis K provides a measure of the "thickness" of the tails of the distribution (Equation 4.). For a normal distribution K equals 0. In equations 7. and 8., s is a standard deviation of y_t. Statistical significance of S and K can be measured with chi-square distributed Jarque-Bera statistic JB (Equation 9.). (Pindyck and Rubinfield 1997: 45-48)

$$S = \frac{T}{(T-1)(T-2)} \frac{\sum_{t=1}^{T} (y_t - \bar{y})^3}{s^3} \tag{7.}$$

$$K = \frac{T(T+1)}{(T-1)(T-2)(T-3)} \frac{\sum_{t=1}^{T} (y_t - \bar{y})}{s^4} - \frac{3(T-1)^2}{(T-2)(T-3)} \tag{8.}$$

$$JB = \frac{N}{6}(S^2 + K^2/4) \tag{9.}$$

4.2 Helsinki Stock Exchange: trading mechanism and recent trends

In this chapter market structure and trading mechanism of Helsinki Stock Exchange is introduced. Summary of the recent trends of the Finnish economy and the Helsinki Stock Exchange are also presented to give background knowledge about factors, which have impacted on equity market during the research period.

4.2.1 Trading mechanism of Helsinki Stock Exchange

The trading of equities in Finland is concentrated on the Helsinki Stock Exchange, founded in 1912. During 1997 Helsinki Stock Exchange and SOM (Finnish options exchange) announced to merge, and after joining the operations they currently form a new exchange called as HEX Ltd., Helsinki Security and Derivatives Exchange, Clearing House. In addition to the Main list, shares are also currently quoted on smaller I- and NM-lists. Until August 1996 Finnish Association of Security Dealers also maintained OTC- and stockbrokers lists that were transferred to HEX.

The Helsinki Stock Exchange has operated as a limit order book market since 1989. The new trading mechanism replaced old batch auction –based system that had been in use since 1935. Shares were gradually moved from the batch auction to LOB trading throughout 1989.

Trading day begins with an opening of trading session that begins at 9.00 and ends at 9.40. During the opening phase, the brokers enter their sell and buy orders into the HETI trading system. At this time, the offer data are not yet public and the brokers can only see their own offers on their monitors and no actual trading takes place. Between 9.40 and 10.00 a batch auction pre-trading session takes place. Sell and buy orders entered during the opening phase are automatically matched as transactions. Unmatched and odd-lot orders are directly transferred to the next trading session, the continuous trading. In connection with matching, opening prices are quoted for each security. Continuous trading between 10.00 and 18.00 is still preceded by two after-market sessions (18.03-18.30 and 8.30-9.00 on the next trading day). Bids and asks during the two after-market sessions must be made at or between the highest and lowest transaction prices of the continuous trading, or alternatively at or between best bid and ask prices available in the limit order book at the end of the continuous trading session, if this widens the range. Continuous trading yet continues with evening trading from 18.03-20.00. The mentioned time-schedule prevails from April 2nd 2002 onwards. During 1990-2002 the continuous trading session has been extended or changed several times. (http://www.hexgroup.com)

Characteristic for LOB markets, there are no designated market makers posting firm quotes in order to be ready to buy or sell shares, but brokers as members of the exchange post investor's orders to the limit order book. Brokers trade mainly for their customer's account, but are also at the customer's permission allowed to trade through the account of the brokerage firm. On HEX orders must have a specified price and quantity, i.e. there are no market orders except for odd lot matching. In this feature HEX differs from many other LOB systems used on other exchanges (Hedvall 1994: 25). If an order that is similar to an incoming order in subject to price and quantity, both of the orders are automatically matched by the HETI-system of HEX and cleared from the order book. If a matching order does not exist, the incoming order stays in the limit order book, waiting to be executed later. Limit orders in the limit order book are sorted first by price priority and then by time priority, i.e. an order with a best price is executed first and orders with a same price are executed in the order of submission. (http://www.hexgroup.com)

On HEX normal real-time continuous trading chiefly covers trade of round lots. In trading of odd lots, the HETI system matches suitable bids and offers into transactions in real time and the price level is determined on the basis of the latest transaction in round lots. During the continuous trading trades can also be executed as negotiated trades outside the limit order book. The buyer and the seller agree on a transaction between themselves, and trades are reported to the exchange after the execution. Negotiated trades must be executed at or between the best bid and ask prevailing in the order book at the time. Negotiated trades are typically large in-house trades arranged by the same broker representing both the buyer and the seller. Trading in large lots is also possible to arrange as block trading, when a buyer and seller agree on the transaction between themselves and the trade size fulfils the requirements. In block trade, the buyer and the seller agree on a transaction between themselves. The price term of the transaction is not restricted. (http://www.hexgroup.com)

On HEX whole content of the order book is made visible to all brokers. High degree of transparency is traditionally regarded as important on exchanges, as it has been suggested to improve liquidity by reducing the opportunities to take advantage of less informed traders. For instance, Pagano and Roell (1996) argue that expected trading costs averaged over all trade quantities will be lower in more transparent markets.

4.2.2 Recent trends of the Finnish economy and stock market

During the 1990's Finnish economy and financial markets experienced several changes. Vaihekoski (1997a) names two important recent economic events, which have had a major impact for both the Finnish economic development and financial markets. First, after economic boom and GNP growth of 4.1% - 5.7% during 1987-1989 Finland faced a severe economic downturn in 1989-1992. During 1990-1993 GNP declined by almost 12% and unemployment rate increased dramatically. In connection with the recession Finnish economy also suffered from wide banking crisis, boosted by banking liberalization process, falling equity prices and company profits, high interest rates and credit boom in the mid-1980's. However, economic growth improved during the second half of the 1990's.

The second important trend in Finnish economy in the 1990's concerns the general liberalization of the trade and the European integration processes. A major step in this process was the joining the European Union in 1995 and European Monetary Union, preceded by free-trade agreements with EEC in 1972 and European Union in 1992.

The economic cycles are also reflected in stock markets (Figure 1). The recession at the beginning of the 1990's notably weakened stock returns. The negative development continued until mid-1993. For instance, in the three-year period 1989 share prices fell by approximately 75%. After mid-1993 stock prices began to rise rapidly with the improved macroeconomic development and clearly surpassed the pre-recession level. The great success was partly due to Nokia Corporation, which e.g. at the end of 2000 solely accounted for approximately 70% of the total market capitalization. Especially high returns at the end of the 1990's can be explained by the international boom of hi-tech stocks and high share of these companies on the Helsinki Stock Exchange.

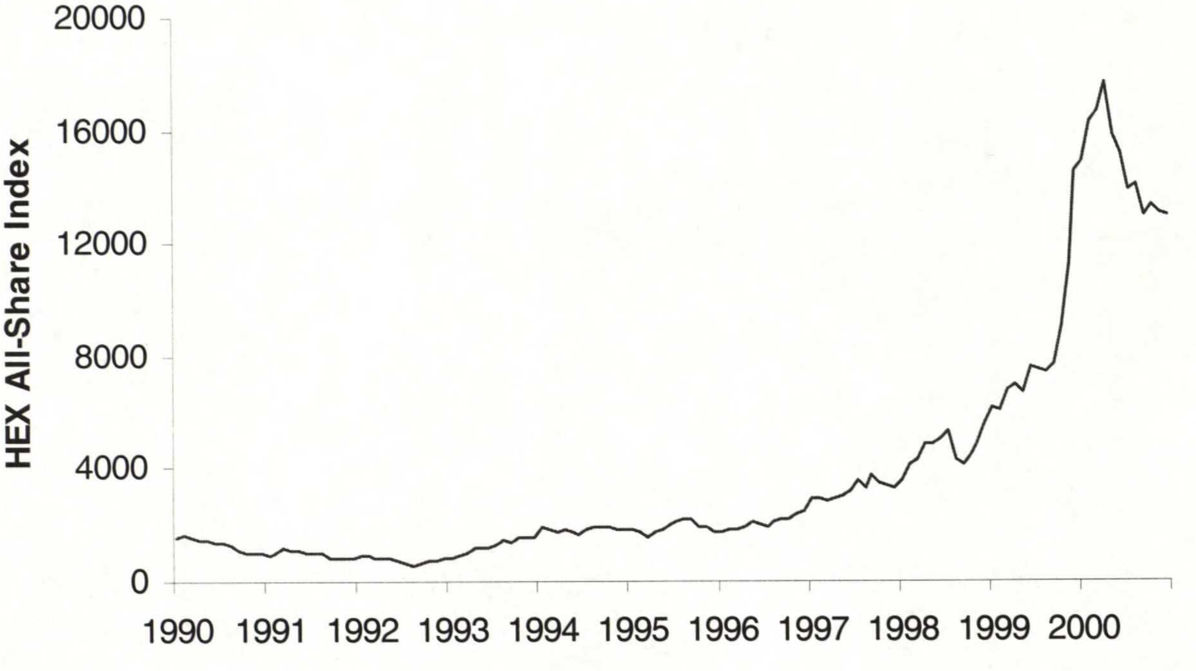

Figure 1. HEX General Index 1990-2000.

Institutionally, the greatest changes of Finnish financial markets during the last decade were related to liberalization and internalization. Finnish financial markets were a long time relatively weakly developed compared to many other Western countries, potentially due to scarcity of capital and investors, re-borrowing of employee pension funds, importance of intermediated finance and banks and peculiarities of tax systems. As a result, trading has been thin and price formation slow (Martikainen et al. 1994). The Finnish financial system was tightly regulated (e.g. interest rates were not determined by money supply and demand) and legally isolated from international capital markets. (Finnish Bankers' Association 1996).

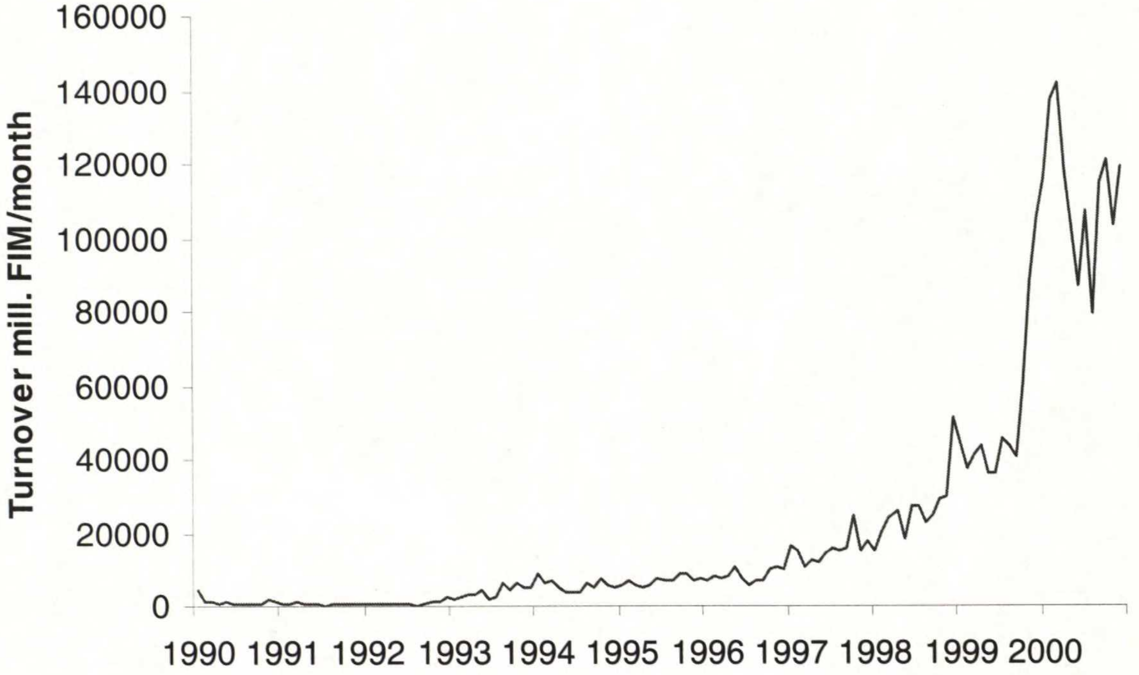

Figure 2. Trading volume of equities and subscription rights on Helsinki Stock Exchange 1990-2000.

However, the general liberalization and internalization process improved foreign investors' possibilities to buy Finnish shares. The final step of the liberalization process was the removal of all restrictions on foreign ownership beginning in January 1993, preceded by gradual increases of the maximum of unrestricted equity capital of Finnish companies and removal of the transfer duty of 1.6% for trades where both parties were foreign. The liberalization process increased foreign investors' interest in Finnish companies, and proportion of market capitalization owned by foreigners increased from approximately 5% at the beginning of 1990 to over 70% at the end of 2000. At the same time Finnish investors have also diversified abroad. Also other judicial changes supported the liberalization process of equity markets, such as removal of tax disadvantage of equity investments in 1993 and the inception of the new Securities Markets Act in August 1989 and its later amendments, replacing previous self-regulation of the market. Finnish legislation was also changed to comply with European Union directives related to investment services and market risks. As a result, Helsinki Stock Exchange has become internationally much more competitive marketplace. In addition to equity markets, liberalization impacted also on other sections of financial markets. For instance, derivative markets and mutual funds started operating in the late 1980's. Capital of mutual funds at the end of 2000 was over 250 times than at the end of 1990 (www.sijoitusrahastot.fi). Compared to intermediated finance, role of financial markets as a financial source has also increased notably in the 1990's (Finnish Bankers' Association 2001: 6). (Vaihekoski 1997a)

The mentioned structural changes, increased interest in equity finance, decreased importance of bank and other intermediated finance, new capital raised from the market, new listings and boom at the end of 1990's have probably all contributed to dramatically increased trading volume of equities on HEX (Figure 2.).

4.3 Research data

4.3.1 Liquidity variables

Liquidity variables used in this study are based on trading volume and bid-ask spread fourchette of independent stocks on Helsinki Stock Exchange, during years 1990-2000 (see Table 2.)

Continuous LOB-markets lack market makers posting bid-ask spreads. Therefore, on Finnish market fourchette is probably the best possible measure of bid-ask spreads. Fourchette describes difference between the best available limit buy order and the best limit sell order in the order book at a certain time (Hedvall 1994: 97). During the trading day fourchette is constantly changing, but in statistical studies fourchette based on daily close buy and sell orders is usually used due to unavailability of more precise data. This is also the case in this study. Consistent with many earlier studies (e.g. Hansson 1995, Hedvall 1994, Laux 1993) spread is measured as a proportional, dividing absolute spread with quote midpoint (Formula 10.).

$$Proportional\ spread = \frac{2(ask - bid)}{ask + bid} \tag{10.}$$

As interest of this study is especially in market-level liquidity, aggregate measures consisting of spreads of individual shares is used. In finance research using value-weighted averages is relatively usual, as importance of big companies for the whole market is greater than small companies. After all, forming a value-weighted market bid-ask spread in a sense describes a bid-ask spread an investor holding a portfolio identical to value-weighted market index is facing. As value-weighted market bid-ask spread is used a variable provided by Mika Vaihekoski of LTT Research Ltd measured monthly for years 1990-2000 (ValueSpread). It is composed by calculating first monthly arithmetic averages of daily close proportional spreads for every company listed on HEX Main list (previous Official list) during the whole month in question, excluding companies on smaller lists. Second, market-level spread is composed by calculating a value-weighted average of individual companies' monthly spreads, based on company values at the end of the previous month.

The described value-weighted market spread has advantages, but also disadvantages. First, using all the companies on the main list changes content of the list in the long run, as some new companies get listed and some other companies leave the list. Second, divergent value changes between companies may change value of the variable, even if market liquidity would not change. Due to great weight of individual companies, especially Nokia, on the Finnish market risks for distorted results would therefore be considerable. As companies have different spreads due to company-related differences, Chordia et al. (2001) compose their market-level spreads using only companies that are present on the list during the whole research period, and use arithmetic averages instead of value-weighted ones. In this study arithmetic averages (ArithmeticSpread) are composed based on Hese database provided by Helsinki School of Economics, using the most traded stock series of 20 big companies that are present on the list all the time 1990-2000. ArithmeticSpread is composed of daily close spreads, and in addition to monthly values of ValueSpread they are also calculated on weekly and daily basis. Monthly and weekly values are averages of daily values.

The amount of used companies is relatively small compared to sample of Chordia et al (2001). However, amount of companies existing on the main list all the time frame is relatively limited. Calculating bid-ask spreads also requires that bid and ask quotations exist: without quotations spread is undefinable. The clearest solution would be a removal of companies unless they have bid and ask quotations for the whole research period. Unfortunately this kind of procedure would in practise delete almost all the companies from the Finnish data, especially due to thin trading in the beginning of the 1990's. Numerous mergers, acquisitions and changes of trading codes also cause additional problems in applying the mentioned simple filter rule. One possibility is to calculate averages using only stocks trading on each day. However, infrequently trading shares probably have higher than average spreads, and therefore changes in spreads can be driven by such shares moving in and out of the sample. Similarly to Chordia et al. amount of companies in the sample was same all the time. When a share lacked quotations, the previous value was used. Naturally, the problem of this method is existence of non-current data. I think that including 20 companies is a reasonable compromise between the most representative sample and use of non-current values. Amount of trading days lacking quotations changed from 0 to 28 depending on the company in question, and for most of the companies the number is below 10. Due to small amount of data the sample also includes some mergers. To keep the amount of companies similar only other of merging companies is present in the sample before the merger in these cases. Table 1. includes the list of used companies.

Fourchette has many problems as a liquidity measure (see Chapter 2.2.2), as it does not necessarily describe reliably spreads investors have to pay in practise, especially when fourchette describes the situation only at the end of the trading day. However, considering the available data this is probably the best possible way to measure spreads. Chordia et al. (2001) also report that spreads calculated with more complicated techniques correlate notably with simple quoted spreads. Additionally, Hedvall (1994: 144-146) documents that during more liquid periods ("degree of liquidity" defined with several measures, including also some more sophisticated ones, e.g. market depth) fourchette tends to be lower on the Helsinki Stock Exchange. For these reasons, fourchette can be regarded as a proxy for market liquidity. However, the fact that in this study fourchette is solely based on daily close quotations due to availability of data causes additional problems. As the statistic describes the liquidity situation only at the end of trading session, it perfectly ignores the rest of the day. In principle, the statistic is under these circumstances defective to describe daily liquidity. In addition to the conceptual problem this may in practise increase amount of variance of data and outliers, if quotations for some reason deviate from their "normal" level at the end of trading. In this case, daily close fourchette would measure daily liquidity poorly. However, averaging fourchettes of several companies probably decreases effect of this problem.

Table 1. Companies used in construction of liquidity variables

Company name at the end of 2000	Previous names
Amer	-
Finnair	-
Fiskars	-
Huhtamäki Van Leer	Huhtamäki
Kesko	-
Kone	-
Instrumentarium	-
Metso	Valmet
Metsä-Serla	-
Nokia	-
Nordea	SYP, Merita
Outokumpu	-
Partek	-
Pohjola	-
Rautaruukki	-
Sampo	-
Sanoma-WSOY	WSOY
Stora-Enso	Enso
UPM-Kymmene	Kymmene
Wärtsilä	Metra

Composition of trading activity variables is simpler, as market trading activity can be formed based on a sum of trading activity of all individual stocks without calculating averages. Days without trading are not a problem either. In this study trading activity is calculated as monetary trading volume, i.e. number of shares multiplied by transaction prices. The total monthly market trading volume of equities on Helsinki Stock Exchange for 1990-2000, including also smaller lists, is provided by ETLA database (TotalVol). As also total volume is sensitive to new listings and exchange leavings, trading volume using only 20 big companies that were present on the data all the research period was calculated using Hese database (Vol). As weight of Nokia Corporation is so considerable, measure VolNokOff is also formed by reducing volume of Nokia from Vol. Hence, VolNokOff does not react to company-related factors of Nokia, which due to huge weight of Nokia would change total market volume considerably. For Vol and VolNokiaOff it was also possible to calculate daily and weekly turnover, in addition to monthly volume.

As stock returns are potential explaining variables of trading activity, trading volume deflated with stock returns are also calculated (DefTotalVol, DefTotalVolNok, DefVol). Without this correction, during rising equity prices monetary volume would increase without changes in trading activity measured by number of traded stocks and vice versa. For deflating of TotVol value-weighted HEX All-Share index was used, and for other measures HEX Portfolio index where a weight of an individual company is limited to 10%. Deflation is calculated according to Formula 11, where Vol_t is trading volume, P_t price index value and P_0 price index value at the beginning of the data period.

$$Deflated\ volume_t = \frac{Vol_t}{1+\frac{P_t - P_0}{P_0}} \tag{11.}$$

Table 2. Liquidity variables

Symbol	Definition
ArithmeticSpread	Arithmetic average of fourchettes of 20 major companies listed on HEX all the research period
ValueSpread	Value-weighted average of fourchettes of all companies on the Main list
TotalVol	Total monetary trading volume of equities on HEX
Vol	Monetary trading volume of 20 companies listed on HEX all the research period
VolNokiaOff	Monetary trading volume of 20 companies listed on HEX all the research period subtracted by volume of Nokia Corporation
DefTotalVol	TotalVol deflated by HEX All-Share index
DefVol	Vol deflated by HEX Portfolio index
DefVolNokiaOff	VolNokiaOff deflated by HEX Portfolio index

In regression models chiefly changes in variables are used instead of absolute values, as this is expected to decrease potential econometric problems (see Chapter 4.2.2). All changes are calculated as differences in the logarithm of the absolute values. Logarithmic changes are used instead of "straight" percentual changes, as they should increase normality of the data. The distribution of straight percentual changes is necessarily skewed to the right, as a change from e.g. 500 to 1000 is 100% but from 1000 to 500 only –50%. The respective changes using logarithmic changes would have been 69,3% for both directions. Normality is advantageous, as it is one of the assumptions of the regression model.

4.3.2 Explanatory variables

Used explanatory variables cover years 1990-2000 on Helsinki Stock Exchange. Used variables are presented shortly in Table 3.

Variables R_g and R_p are measures of market returns using different value-weighted indices provided by HEX database of Helsinki School of Economics. R_g represents HEX All-Share index (HEX General index) and R_p HEX Portfolio index, where weight of one individual company is limited to 10%. In regression models R_p is used for variables, in which natural weight of Nokia Corporation is reduced. However, portfolio index was available only from the beginning of 1991, and the missing year 1990 is therefore replaced by All-Share Index in regressions. This should not be a big problem, as weight of Nokia Corporation was then not excessive. Daily market returns are measured as logarithmic differences of index values, weekly and monthly returns are calculated as cumulative returns based on daily returns. In addition to R_g and R_p also variables $R_{g,t-1}$ and $R_{p,t-1}$ are used in regressions as measures of lagged market returns. The mentioned indices are value-weighted and corrected for cash dividends, splits, stock dividends and new issues. (for additional information about index calculations see e.g. http://www.hexgroup.com/pdf/hexlaskentaesite.pdf).

$Vola_t$ measures equity price volatility on the market. Standard deviation is a popular volatility measure, but as shown by Cohen et al. (1983) existence of autocorrelation may distort sample standard deviation. As autocorrelation is one of the characteristics of Finnish stock returns (Knif and Löflund 1997), more simple proxy used by Chordia et al. (2001) is utilized. It is calculated by taking an arithmetic average of daily absolute returns during the period in question, i.e. weekly volatility is an average of returns during the week and monthly volatility is an average of returns during the month in question. As intradaily data was not available, on daily level absolute return of the day in question was used as volatility measure. $Vola_t$ is calculated based on either HEX All-Share index or HEX Portfolio index, depending on which index is used as a proxy for market return.

USD_t and $IB3_t$ describe logarithmic changes in FIM/USD (from the beginning of 1999 EUR/USD) exchange rates and three-month Helibor (from the beginning of 1999 Euribor) interbank interest rates. Daily and monthly series were available in ETLA Database, and weekly series were formed by averaging daily values of the week. $VolaUSD_t$ and $VolaIB3_t$

measure the volatility of these variables, calculated as volatility of market returns described above. $BondVol_t$ describes turnover of bond market, measured as a logarithmic change of monetary trading volume of bonds on Helsinki Stock Exchange. Potential of the interest rate term spread as an explaining variable is also tested, calculated as a change in difference between the 12 month and 1 month interbank rates($TSpr_t$). Exceptionally this variable was formed without logarithmic transformation, as using logarithms in connection with negative values yields indefinable results. All the interest and exchange rates are used in daily, weekly and monthly regressions, despite of bond turnover, which was available only on monthly level.

Table 3. Explanatory variables

Symbol	Definition
$R_{g,t}$	HEX All-Share Index Return
$R_{p,t}$	HEX Portfolio Index Return
$R_{g,t-1}$	Lagged HEX All-Share Index Return
$R_{p,t-1}$	Lagged HEX Portfolio Index Return
$Vola_t$	Volatility of market return measured as an arithmetic average of absolute daily market returns during the measuring interval
USD_t	Logarithmic change in the FIM/USD exchange rate
$IB3_t$	Logarithmic change in the 3-month Helibor (Euribor) rate
$TSpr_t$	Change in difference between the 12-month and 1-month Helibor (Euribor) rates
$VolaUSD_t$	Volatility of the FIM/USD exchange rate measured as an arithmetic average of absolute daily rates during the measuring interval
$VolaIB3_t$	Volatility of 3-month Helibor (Euribor) rate measured as an arithmetic average of absolute daily rates during the measuring interval
$BondVol_t$	Monetary trading volume of bonds on Helsinki Stock Exchange
Monday-Thursday	1.0 if trading day is Monday, Tuesday, Wednesday or Thusday and 0 otherwise
January-November	1.0 if trading day is January, February, March, April, May, June, July, August, September, October, November and 0 otherwise
USHoliday	1.0 if trading day is U.S. holiday and 0 otherwise
Holiday	1.0 if trading day is preceding or following a major holiday

Additionally different seasonal dummies are included in the regression models. In daily regressions weekday dummies Monday, Tuesday, Wednesday and Thursday are used and in monthly regressions month names except December operate as dummies. USHoliday dummy represents U.S. holidays (Martin Luther King Jr. Day, Washington's Birthday, Good Friday, Memorial Day, Independence Day, Labor Day and Thanksgiving Day) indicating absence of

U.S. investors from trading of Helsinki Stock Exchange. Additionally, Holiday dummy register days around major Finnish holidays (New Year, Easter, First of May, Midsummer, Independence day and Christmas holidays). As a calendar a world calendar provided by Time and Date.com was used (www.timeanddate.com/calendar/).

5 Empirical results

In this chapter empirical results are presented.

5.1 Descriptive statistics

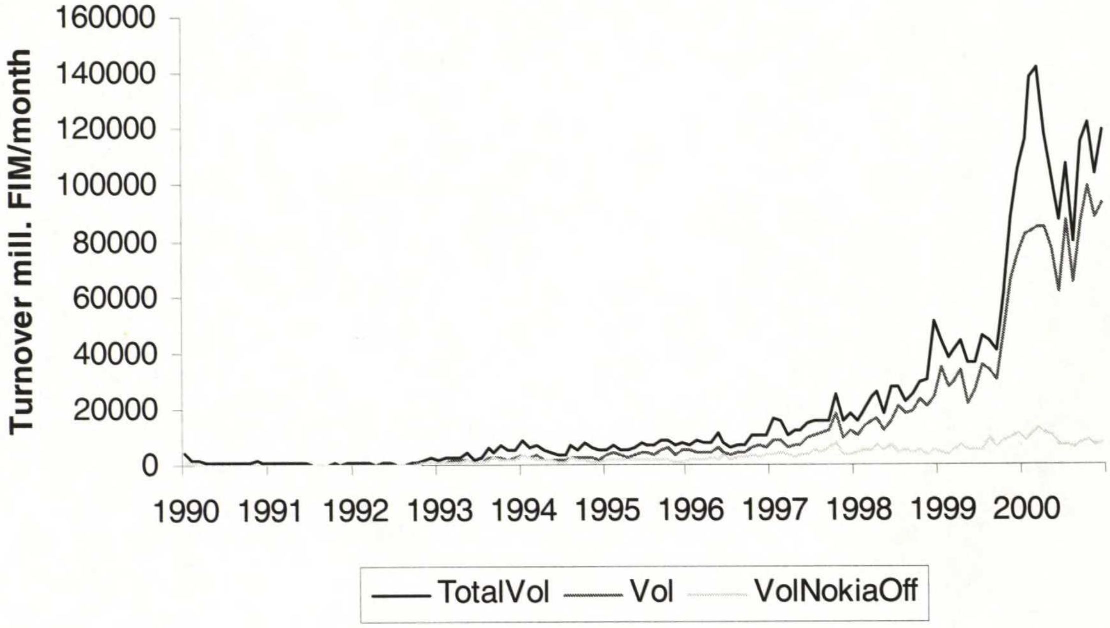

Figure 3. Development of liquidity variables based on trading volume. TotalVol is total market trading volume, Vol trading volume of a portfolio of 20 major companies and VolNokiaOff Vol subtracted by volume of Nokia Corporation.

Figures 3.-5. show development of used liquidity variables used in the study. Variables based on trading volume decrease during the first years of the 1990's suffering from economic downturn and grow steadily during the mid-90's. The last years of the decade were characterized by aggressive growth, due to economic upturn and international boom of high-tech stocks. However, much of the growth at the end of 1990's is explained by the success of Nokia Corporation. Variables based on trading volume deflated by equity market index show similar trends, although peak at the end of 1990's naturally is considerably lower. However, increasing trend of deflated trading volume show that all increase in monetary trading activity cannot be explained only by increase in equity prices. Structural changes in Finnish equity market described in Chapter 4.2 are potential drivers of this positive trend of trading activity on HEX throughout the 1990's, in addition to improved economic cycles. Such changes are e.g. liberalization and internalization of Finnish equity markets, removal of tax disadvantage of equity investments and decreased importance of bank and other intermediated finance.

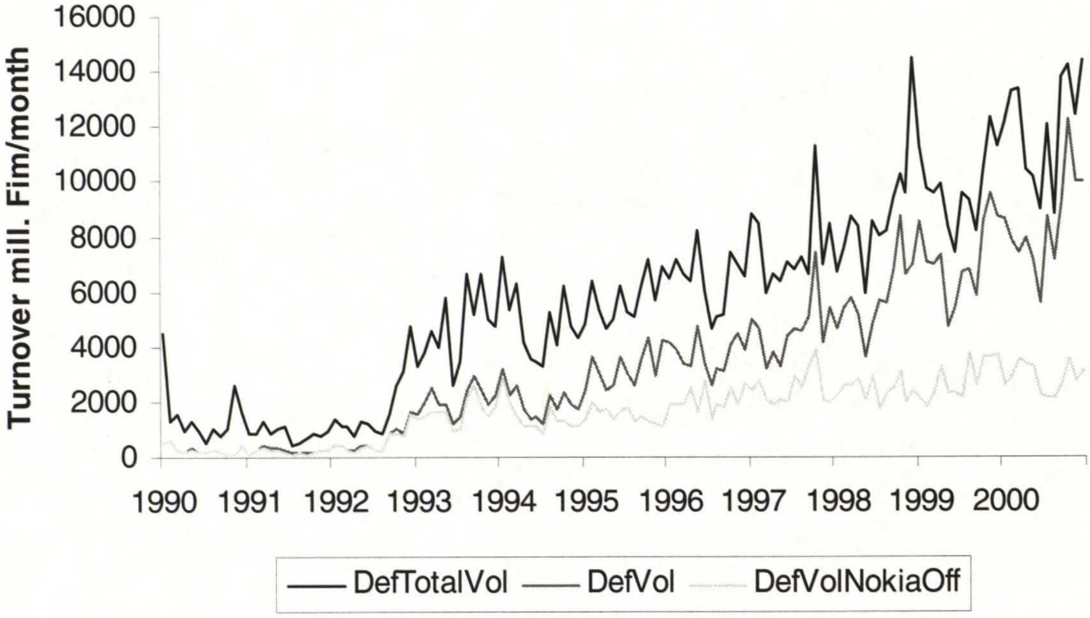

Figure 4. Development of liquidity variables based on trading volume deflated by equity market return index. TotalVol is deflated total market trading volume, Vol deflated trading volume of a portfolio of 20 major companies and VolNokiaOff Vol subtracted by deflated volume of Nokia Corporation.

Liquidity variables based on bid-ask spreads show just the opposite development, as expected. Rising trend of trading has increased competition between investors, and this has lead to decreasing spreads on the equity market. In addition to increased trading activity, increased interest in equity markets may have improved amount and quality of information submitted by companies and other parties, e.g. analysts of banking firms. In theory, this should improve investors' perceptions of equity prices, decrease threat of asymmetric information and hence drive down spreads.

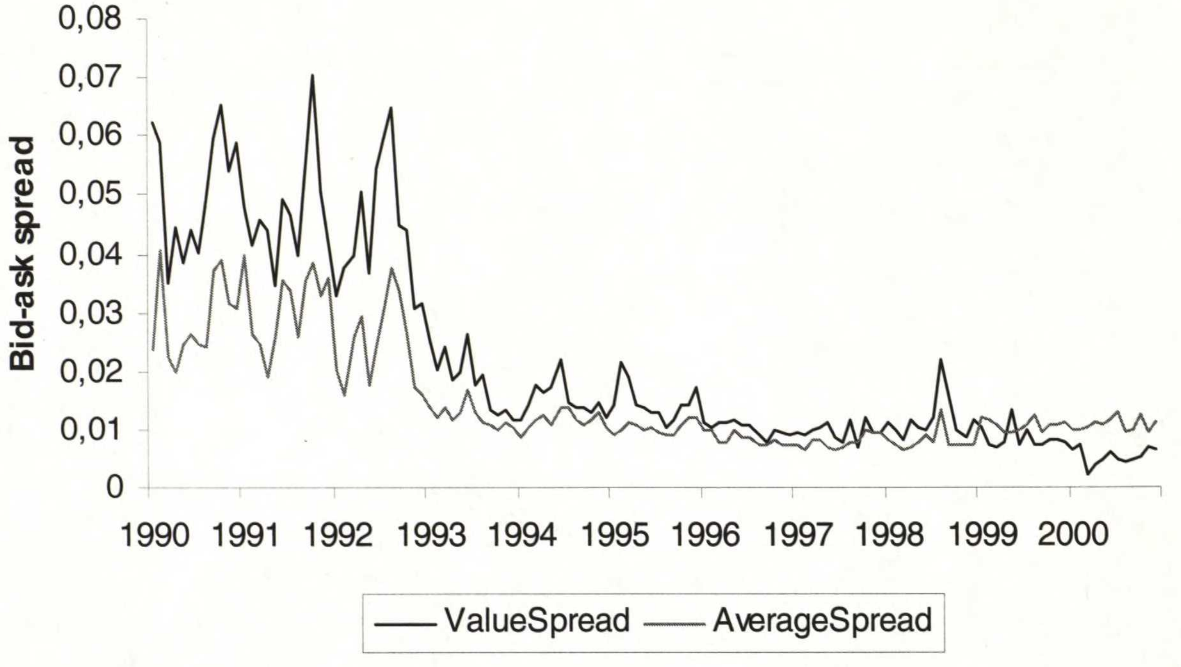

Figure 5. Development of liquidity variables based on bid-ask spreads. AverageSpread is arithmetic average of fourchettes of 20 major companies, ValueSpread value-weighted average of fourchettes of all companies listed on the HEX Main list.

Table 4. presents some descriptive statistics for used liquidity and explaining variables. Like pictures 4. and 5., average changes of liquidity variables show improved liquidity during the 1990's. Compared to market returns liquidity attributes appear very volatile, especially on higher data frequencies. Based on Jarque-Bera test, distribution of used liquidity variables seem to deviate from normal distribution, despite of use of logarithmic differences. The phenomenon is especially noticeable on higher data frequencies, and is mainly caused by high kurtosis. Consistent with previous studies, also other financial time series deviate from normal distribution, especially with higher data frequencies (see e.g. Knif and Löflund 1997 for statistical distributions of Finnish equity returns). Different volatility measures generally deviate from normal distribution the most, as they also suffer from high skewness in addition to kurtosis, possibly due to their impossibility to have negative values.

Table 4. Desciptive statistics for liquidity and explaining variables

Sample sizes are 2751 daily, 571 weekly and 131 monthly, sample period is 1990-2000. Liquidity variables are logarithmic differences of absolute values. Acronyms ArithmeticSpread and ValueSpread denote different measures of market-wide bid-ask spreads, TotalVol, Vol and VolNokiaOff market trading volumes and DefTotalVol, DefVol and DefVolNokiaOff trading volumes deflated by market index. The null hypothesis of the normal distribution is tested using Jarque-Bera test, test statistic statistics significant at the 1 (5) percent level are indicated by ** (*).

Time series	Data frequency	Mean	Standard Deviation	Skewness	Excess Kurtosis	Jarque-Bera statistic
Liquidity variables						
ArithmeticSpread	daily	-0.000	0.274	0.143	0.560	44.079**
	weekly	-0.001	0.184	0.082	1.414	46.779**
	monthly	-0.010	0.203	-0.109	1.217	8.157*
ValueSpread	monthly	-0.127	0.265	-0.572	3.299	67.051**
TotalVol	monthly	0.028	0.341	-0.364	1.079	9.329*
Vol	daily	0.002	0.630	-0.034	5.367	3304.052**
	weekly	0.011	0.518	-0.338	2.032	109.056**
	monthly	0.039	0.388	0.185	2.393	31.991**
VolNokiaOff	daily	0.001	0.658	0.020	5.143	3032.874**
	weekly	0.006	0.534	-0.300	2.214	125.182**
	monthly	0.021	0.406	0.331	2.112	26.743**
DefTotalVol	monthly	0.009	0.317	-0.469	1.867	23.825**
DefVol	daily	0.001	0.629	-0.027	5.387	3328.21**
	weekly	0.007	0.516	-0.318	2.082	112.733**
	monthly	0.022	0.369	0.493	3.053	56.188**
DefVolNokiaOff	daily	0.001	0.657	0.022	5.165	3059.63**
	weekly	0.005	0.530	-0.302	2.282	132.590**
	monthly	0.014	0.389	0.538	2.697	46.023**
Explanatory variables						
R_{mt} (HEX All-Share index return)	daily	0.001	0.017	-0.381	9.620	10682.092**
	weekly	0.004	0.041	-0.195	2.520	154.943**
	monthly	0.016	0.087	0.128	0.696	3.023
R_{mt} (HEX Portfolio Index return)	daily	0.001	0.013	.0.183	2.967	931.601**
	weekly	0.003	0.032	-0.063	0.749	12.527**
	monthly	0.011	0.074	-0.049	1.041	5.467
$Vola_t$ (HEX All-share index volatility)	daily	0.012	0.013	3.316	21.487	58006.193**
	weekly	0.012	0.009	2.117	5.723	1207.708**
	monthly	0.012	0.007	1.634	2.770	100.921**
$Vola_t$ (HEX Portfolio index volatility)	daily	0.009	0.009	2.128	7.077	7822.571**
	weekly	0.009	0.005	1.809	5.522	946.362**
	monthly	0.008	0.004	0.349	1.171	10.213*
USD_t (Change in FIM/USD)	daily	0.000	0.008	3.932	73.115	620294.738**
	weekly	0.001	0.017	1.719	16.536	6799.279**
	monthly	0.004	0.028	0.289	0.995	7.293
$IB3_t$ (Change in 3-month interest rate)	daily	-0.000	0.021	-0.480	85.935	847196.806**
	weekly	-0.002	0.033	0.212	7.902	1492.645**
	monthly	-0.009	0.062	0.047	1.779	17.463**
$TSpr_t$ (Term spread)	monthly	0.004	0.372	0.693	9.060	462.006**
$VolaUSD_t$ (FIM/USD volatility)	daily	0.005	0.001	9.455	191.083	4229305.475**
	weekly	0.005	0.003	5.593	55.981	77671.990**
	monthly	0.005	0.002	3.227	18.082	2027.539**
$VolaIB3_t$ (Interest rate volatility)	daily	0.009	0.019	8.665	112.851	1495311.226**
	weekly	0.009	0.012	5.407	43.172	47207.557**
	monthly	0.009	0.008	1.988	4.635	205.077**
$BondVol_t$ (Change in bond market volume)	monthly	-0.033	1.086	-0.472	3.364	67.118**

Table 5. presents sample autocorrelation coefficients of used variables out to a lag five. Consistent with Chordia et al. (2001), changes in market-wide liquidity attributes seem to autocorrelate negatively. Every series exhibits significant negative first-order sample autocorrelation, and in some series coefficients are significant even with longer lags. There can be several explanations for the phenomenon. First, if it is assumed that trading activity is mostly information-based and changes according to intensity of announcements of new information, negative autocorrelation may indicate that seasons characterized by high amount of information announcements is followed by seasons of smaller news frequency. For instance, weeks of several earnings announcements and high liquidity would be followed by weeks of smaller trading according to this theory. According to Chordia et al. (2001), negative first-order autocorrelation of could arise also from discreteness. In the short run spreads are probably quite discrete, e.g. 10 or 20 cents. If some stocks oscillate between these points as a correlated group, this would produce negative autocorrelation. Naturally, data recording errors and problems in forming aggregate variables are also potential reasons for such behaviour. However, the negative autocorrelation also appeared in all single stocks and not only in largest ones, which might distort aggregate measures. The evidence suggests that negative autocorrelation is a basic feature of the time series process of liquidity of Finnish equity markets utilizing trading volume and spreads.

Explanatory variables based on volatilities show high positive autocorrelation that seems to be higher when longer periods are used. Autocorrelation also stays positive with longer lags. Especially stock market return volatility autocorrelation is high. One potential reason is changes in index composition, e.g. relative value of stocks with high volatility rises. Based on visual inspection of the volatility data, it seems that stock market volatility gets its highest values during the last years of the data. For instance, boom of high-tech stocks characterized by high volatility and their increasing weight may have increased average index volatility at the end of 1990's and this induces high positive autocorrelation. If volatility is measured with Portfolio Index that limits weight of individual high-tech stocks, autocorrelation is smaller. Also monthly interest and exchange rate volatilities seem to autocorrelate strongly. Possibly impact of background macroeconomic factors may cause this clustering of volatilities on used data frequencies. As a matter of fact, this kind of behaviour is characteristic for many financial time series (see e.g. Bollerslev et al. 1992).

Table 5. Sample autocorrelation coefficients of liquidity and explaining variables

Sample sizes are 2751 daily, 571 weekly and 131 monthly, sample period is 1990-2000. Liquidity variables are logarithmic differences of absolute values. Acronyms ArithmeticSpread and ValueSpread denote different measures of market-wide bid-ask spreads, TotalVol, Vol and VolNokiaOff market trading volumes and DefTotalVol, DefVol and DefVolNokiaOff trading volumes deflated by market index. Autocorrelation coefficients significant at the 1(5) percent level based on Bartlett test are indicated by ** (*).

Time series	Data frequency	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5
Liquidity variables						
ArithmeticSpread	daily	-0.432**	-0.022	-0.014	0.018	-0.061**
	weekly	-0.348**	0.046	-0.089*	0.086*	-0.063
	monthly	-0.199*	-0.251**	0.036	0.060	-0.103
ValueSpread	monthly	-0.320**	-0.062	-0.059	0.019	0.017
TotalVol	monthly	-0.242**	-0.110	0.085	-0.074	0.105
Vol	daily	-0.407**	-0.061**	-0.038*	0.045*	-0.030
	weekly	-0.348**	-0.100*	-0.051	0.067	0.016
	monthly	-0.234**	-0.201*	0.166	0.025	-0.143
VolNokiaOff	daily	-0.424**	-0.049**	-0.015	0.026	-0.025
	weekly	-0.356**	-0.106*	0.004	-0.024	0.091*
	monthly	-0.281**	-0.125	0.038	0.121	-0.167
DefTotalVol	monthly	-0.302**	-0.077	0.090	-0.094	0.097
DefVol	daily	-0.408**	-0.060**	-0.039*	0.045*	-0.030
	weekly	-0.355**	-0.108**	-0.050	0.072	0.016
	monthly	-0.274**	-0.207*	0.180**	0.019	-0.161
DefVolNokiaOff	daily	-0.426**	-0.049**	-0.016	0.026	-0.025
	weekly	-0.364**	-0.109**	0.005	-0.022	0.091*
	monthly	-0.322**	-0.115	0.027	0.122	-0.176*
Explanatory variables						
R_{mt} (HEX All-Share index return)	daily	0.095**	-0.030	0.010	0.023	0.031
	weekly	0.000	0.072	0.009	-0.005	0.185**
	monthly	0.168	0.045	0.109	-0.055	0.023
R_{mt} (HEX Portfolio Index return)	daily	0.167**	-0.005	0.038*	0.056**	0.061**
	weekly	0.106*	0.066	0.052	0.001	0.145**
	monthly	0.160	-0.025	0.029	-0.053	0.011
$Vola_t$ (HEX All-share index volatility)	daily	0.348**	0.284**	0.282**	0.251**	0.253**
	weekly	0.592**	0.529**	0.528**	0.493**	0.496**
	monthly	0.759**	0.697**	0.598**	0.597**	0.562**
$Vola_t$ (HEX Portfolio index volatility)	daily	0.239**	0.169**	0.198**	0.149**	0.138**
	weekly	0.437**	0.357**	0.334**	0.235**	0.231**
	monthly	0.619**	0.593**	0.414**	0.375**	0.326**
USD_t (Change in FIM/USD)	daily	-0.084**	0.026	-0.048*	0.053**	-0.032
	weekly	-0.027	0.055	-0.067	0.048	0.062
	monthly	0.371**	0.040	0.027	-0.010	0.029
$IB3_t$ (Change in 3-month interest rate)	daily	-0.242**	-0.028	0.042*	0.012	-0.009
	weekly	0.048	0.046	0.061	0.021	0.095*
	monthly	0.412**	0.086	-0.076	0.013	0.063
$TSpr_t$ (Term spread)	monthly	0.194*	-0.209*	-0.353**	-0.145	0.131
$VolaUSD_t$ (FIM/USD volatility)	daily	0.156**	0.098**	0.111**	0.149**	0.115**
	weekly	0.330**	0.230**	0.170**	0.153**	0.148**
	monthly	0.297**	0.285**	0.289**	0.257**	0.234**
$VolaIB3_t$ (Interest rate volatility)	daily	0.424**	0.174**	0.130**	0.117**	0.147**
	weekly	0.325**	0.267**	0.288**	0.355**	0.247**
	monthly	0.701**	0.620**	0.496**	0.489**	0.457**
$BondVol_t$ (Change in bond market volume)	monthly	-0.310**	-0.071	0.096	-0.070	0.043

Slowly declining autocorrelations are a traditional trait of non-stationary time series (Pindyck and Rubinfield 1997: 499-504), and this may cause problems in regression models. Based on formal Dickey-Fuller unit-root tests (Table 6.), none of used time series has unit root at the normally used five percent level. However, on monthly level existence of unit root in some volatility series can not be rejected at the one percent level.

Table 7. reports pair-wise correlation coefficients among changes in used liquidity variables. According to the hypotheses, variables based on bid-ask spreads and trading volume should have negative correlation, i.e. increased volume drives down spreads. According to Table 5., this hypothesis seems to hold: all correlation coefficients between trading volume and spreads are negative. However, correlation coefficients are quite low and statistically significant at the five or one percent level only on monthly level. On higher data frequency correlation stays negative, but is statistically insignificant. Connection between trading volume and spreads is hence quite reliable on used data frequency. This may be due to problems related to using daily close fourchettes as a basis of calculations. Used spread measures may therefore be biased proxies for theoretical market spread. Also, amount of used companies (20) in AverageSpread is quite limited. On the other hand, results may as well indicate that in the short run trading volume and market spread do not correlate even without mentioned measuring problems. These low daily correlation coefficients are quite similar to findings of Chordia et al. (2001) on the U.S. market. This shows that the phenomenon is not necessarily caused by limited data or difficulties in calculating spreads on limit order book markets. Mentioned low correlation between trading activity and spreads may also mean that short-run changes of market liquidity are so noisy that reliable measuring is difficult and depends on used measures. In contrast, monthly correlation coefficient between two used spread measures is clear and statistically significant. Also correlation coefficients of different trading volume measures are high in all data frequencies. Monetary trading volume seems to vary very similarly to trading volume deflated by stock market index.

Table 6. Augmented Dickey-Fuller tests of variables used in time-series regressions

Used form of ADF test uses a model with drift and linear trend, i.e. $Y_t = \alpha + \beta t + \rho Y_{t-1} + \varepsilon_t$. The null hypothesis is $(\alpha, \beta, \rho) = (\alpha, 0, 1)$, i.e. Y_t is a non-stationary random walk process with a drift. F statistics significant at the 1 (5) percent level are indicated by ** (*).

Time series	Data frequency	F statistic
Liquidity variables		
ArithmeticSpread	daily	475.432**
	weekly	141.244**
	monthly	27.757**
ValueSpread	monthly	40.184**
TotalVol	monthly	30.138**
Vol	daily	586.132**
	weekly	234.890**
	monthly	33.801**
VolNokiaOff	daily	534.104**
	weekly	214.648**
	monthly	40.766**
DefTotalVol	monthly	38.153**
DefVol	daily	597.135**
	weekly	213.686**
	monthly	37.163**
DefVolNokiaOff	daily	608.764**
	weekly	221.895**
	monthly	46.414**
Explanatory variables		
R_{mt} (HEX All-Share index)	daily	675.802**
	weekly	122.733**
	monthly	27.783**
R_{mt} (HEX Portfolio Index)	daily	556.994**
	weekly	103.263**
	monthly	26.424**
$Vola_t$ (HEX All-share index)	daily	402.764**
	weekly	31.873**
	monthly	7.653*
$Vola_t$ (HEX Portfolio Index)	daily	388.353**
	weekly	38.661**
	monthly	9.527**
USD_t	daily	716.743**
	weekly	128.672**
	monthly	24.352**
$IB3_t$	daily	623.182**
	weekly	125.242**
	monthly	24.157**
$TSpr_t$	monthly	42.757**
$VolaUSD_t$	daily	500.795**
	weekly	49.862**
	monthly	7.989*
$VolaIB3_t$	daily	600.480**
	weekly	52.170**
	monthly	9.922**
$BondVol_t$	monthly	68.976**

Table 7. Correlation coefficients of liquidity variables

Sample sizes are 2751 daily, 571 weekly and 131 monthly, sample period is 1990-2000. Liquidity variables are logarithmic differences of absolute values. Acronyms ArithmeticSpread and ValueSpread denote different measures of market-wide bid-ask spreads, TotalVol, Vol and VolNokiaOff market trading volumes and DefTotalVol, DefVol and DefVolNokiaOff trading volumes deflated by market index. Correlation coefficients significant at the 1(5) percent level based on t test are indicated by ** (*).

Time series	ArithmeticSpread	ValueSpread	TotalVol	Vol	VolNokiaOff	DefTotalVol	DefVol	DefVolNokiaOff
Monthly								
ArithmeticSpread	1							
ValueSpread	0.398**	1						
TotalVol	-0.277**	-0.076	1					
Vol	-0.184*	-0.022	0.590**	1				
VolNokiaOff	-0.221*	-0.098	0.452**	0.827**	1			
DefTotalVol	-0.165	-0.004	0.971**	0.536**	0.392**	1		
DefVol	-0.123	-0.032	0.542**	0.981**	0.808**	0.519**	1	
DefVolNokiaOff	-0.159	-0.085	0.407**	0.806**	0.987**	0.370**	0.816**	1
Weekly								
ArithmeticSpread	1	-	-					
Vol	-0.051	-	-	1				
VolNokiaOff	-0.078	-	-	0.844**	1	-		
DefVol	-0.033	-	-	0.997**	0.839**	-	1	
DefVolNokiaOff	-0.064	-	-	0.843**	0.998**	-	0.842**	1
Daily								
ArithmeticSpread	1	-	-					
Vol	-0.019	-	-	1				
VolNokiaOff	-0.068	-	-	0.832**	1	-		
DefVol	-0.013	-	-	1.000**	0.832**	-	1	
DefVolNokiaOff	-0.065	-	-	0.832**	1.000**	-	0.832**	1

Table 8. reports pair-wise correlation coefficients of explanatory variables. Without few exceptions coefficients are quite low.

Table 8. Correlation coefficients of explanatory variables

Sample sizes are 2751 daily, 571 weekly and 131 monthly, sample period is 1990-2000. Avronyms denote: Rmt equity market return, Rmt_{-1} lagged equity market return, $Vola_t$ equity market volatility, USD_t change in FIM/USD, $IB3_t$ change in 3-month interest rate $TSpr_t$, change in term spread, $VolaUSD_t$ FIM/USD volatility, $VolaIB3_t$ interest rate volatility, $BondVol_t$ bond market trading volume. Correlation coefficients significant at the 1(5) percent level based on t test are indicated by ** (*).

Time series	R_{mt}	R_{mt-1}	$Vola_t$	USD_t	$IB3_t$	$TSpr_t$	$VolaUSD_t$	$VolaIB3_t$	$BondVol_t$
Monthly									
R_{mt}	1								
R_{mt-1}	0.168	1							
$Vola_t$	0.0566	0.105	1						
USD_t	0.223	0.211*	0.111	1					
$IB3_t$	-0.106	-0.200*	0.123	-0.147*	1				
$TSpr_t$	0.041	0.068	-0.028	0.052	-0.570**	1			
$VolaUSD_t$	0.065	-0.152	0.194*	0.279**	0.279**	-0.166	1		
$VolaIB3_t$	-0.172*	-0183*	-0.267**	0.045	0.045	0.081	0.341**	1	
$BondVol_t$	-0.099	0.035	-0.018	0.005	-0.131	0.067	0.111	0.081	1
Weekly									
R_{mt}	1								
R_{mt-1}	0.000	1							
$Vola_t$	0.011	-0.114	1						
USD_t	0.189*	-0.049	0.022	1					
$IB3_t$	-0.175*	0.018	-0.008	-0.102	1	-			
$VolaUSD_t$	0.064	-0.036	0.180	0.294**	-0.160	-	1		
$VolaIB3_t$	-0.047	-0.070	-0.155	0.0365	-0.091	-	0.263**	1	-
Daily									
R_{mt}	1								
R_{mt-1}	0.095	1							
$Vola_t$	-0.010	-0.060	1						
USD_t	0.154	-0.009	0.034	1					
$IB3_t$	-0.064	-0.042	0.000	-0.020	1	-			
$VolaUSD_t$	0.035	-0.013	0.137	0.275**	-0.068	-	1		
$VolaIB3_t$	-0.008	-0.011	-0.051	-0.051	-0.031	-	0.121	1	-

5.2 Time series regressions

5.2.1 Results of time-series regressions

Estimated time series regressions are presented in Table 9. for market-wide bid-ask spread measures ValueSpread and ArithmeticSpread and trading volume measures TotalVol, Vol, VolNokiaOff, DefTotalVol, DefVol and DefVolNokiaOff. Panel A. includes monthly, Panel B. weekly regressions and Panel C. daily regressions. Sample sizes are 131 for monthly regressions, 571 for weekly regressions and 2751 for daily regressions. According to high Durbin-Watson statistics, traditional OLS-models suffered from negative autocorrelation. These flaws were corrected with GLS-based correction.

The adjusted R^2s of monthly regressions range from 20 to 28 percent, weekly regressions from 17 to 19 percent and daily regression from 14 to 17 percent. The explanatory variables therefore capture an appreciable fraction of time series variation of market-wide liquidity measures. It appears that used explanatory variables capture monthly time series variation the best. As presented above, daily variance of market-wide liquidity measures is especially high. Probably daily data is so noisy that explanatory power of used variables weakens significantly on higher data frequencies. On daily level liquidity changes may also be very strongly driven by existence of unexpected information announcements that are not controlled in this study. Compared to U.S. study employing similar methodology with daily data, adjusted R^2s are some lower (Chordia et al. 2001). In addition to differences between markets, this may be due to more limited data of this study: impact of aggregate explaining variables may decrease, if amount of used companies is small.

Clearly the most important explaining variable of monthly regressions is equity market return $R_{mt.}$ Regression coefficients are statistically significant at the one percent level excluding one exception, and p-value is $9*10^{-7}$ at the lowest. Regression results support the hypothesis: on bullish market trading is more active and bid-ask spreads remain low. This result is consistent with several studies contemplating price-volume relationship (see e.g. Karpoff 1987). There are many explanations for the phenomenon, ranging from costly short selling to different aspects of market psychology. Increased trading also drives down spreads. In addition to increased trading and competition between investors, decrease of spreads on bullish market may also partly be due to used percentual spreads: if equity prices rise, percentual spreads decrease even if differences between bid and ask stay stabile. Positive association between equity returns also applies, when used monetary turnover measures are deflated with equity return. In other words, increased share prices do not fully explain the phenomenon. The described association is also very significant on higher data frequencies, consistent with findings of Martikainen et al. (1994) on daily level.

Compared to contemporaneous equity market return R_{mt}, lagged equity market return R_{mt-1} explains liquidity changes much worse. On monthly and weekly level coefficients are positive for trading activity, but in most of the cases connection is not statistically significant. For spreads monthly coefficients are positive and weekly negative, but statistical significance is clearly lower than significance of contemporaneous return. However, lagged equity return seem to explain better daily variance: coefficients are significantly negative for trading activity and positive for spreads. This result may be due to negative autocorrelation of liquidity variables: if very bullish days are the most liquid, following days are then less liquid. Still, lagged R_{mt-1} explains daily variation of liquidity statistically weaker than non-lagged $R_{mt.}$ It appears that contemporaneous equity return captures most of the explaining power of equity returns.

In addition to equity market return, another important explaining variable is equity market volatility. All data frequencies yielded similar results: increasing volatility is connected with more active trading as expected. This result is also consistent with most of the existing empirical studies of relationship between trading activity and price volatility. Usually this connection is explained by information announcements: interesting unexpected information contemporaneously increases trading and causes price changes (Karpoff 1987). Black (1986) suggests that the phenomenon is due to existence of noise trading. Explanatory power is the weakest on monthly regressions and coefficients are not statistically significant at the one percent level. In weekly and daily regressions explanatory power of equity market volatility rises clearly, with p-values even below 10^{-14}. I assume that connection between information, volatility and trading activity is the strongest on higher data frequencies. If monthly values are used, independent information announcements cancel out and other factors impact more clearly. Volatility measures of different lags may also be important explanatory variables, but in this study they were not studied more closely, chiefly because of high amount of other explanatory variables and limited data on lower data frequencies. Additionally, including several lags of highly autocorrelating volatility measure may induce multicollinearity problems. Martikainen et al. (1994) and Liljeblom and Stenius (1997) have researched this issue more closely.

Based on formed hypotheses, negative connection between volatility and bid-ask spreads was expected. It was expected that high trading volume drives down spreads due to increased competition between investors. However, the results were just the opposite. The connection is significantly positive and increases with data frequency. This result is consistent with studies showing that individual share volatility is cross-sectionally associated with higher spreads (see e.g. Hansson 1995). It is generally assumed that high volatility reflects uncertainty and information asymmetries, and investors react to this by demanding higher ask and lower bid quotations. Even more active trading connected with more volatile prices cannot change this association. In future impact of several lagged values of volatility may be interesting to analyse. Compared to opposite results of Chordia et al. (1995), these results may be due to use of different measuring of volatility: Chordia et al. used volatility of earlier days instead of contemporaneous volatility.

Compared to equity returns and volatility, importance of other used macroeconomic explanatory variables is much more limited. It was expected that interest rate increases decrease liquidity due to increased opportunity costs of short-term trading. I also expected that appreciating Finnish exchange rate is connected with that foreign investors increase their holdings in Finnish equities, causing similarly positive stock market returns and increased liquidity. Macroeconomic volatility was expected to reflect uncertainty and decrease liquidity. Based on regression results impact of interest or exchange rates on market liquidity is not statistically significant, even though signs of coefficients are as expected in most of the cases. However, exchange rate volatility is positively connected with trading activity in weekly and monthly regressions at the five percent level, contrary to the hypothesis. Possibly increased exchange rate volatility is caused by unexpected information that also induces trading on equity market. On the other hand, exchange rate volatility may also reflect change of positions of foreign investors. Contrary to the hypothesis, bond market trading volume has no impact on equity market liquidity. Consistent to Chordia et al. (2001), in monthly regressions decreasing term spread is also associated with active trading at the five percent level. With market-wide bid-ask spreads macroeconomic variables have no statistical connection.

Explanatory power of different seasonal dummies varies. In monthly regressions explaining trading volume most of the monthly dummies (January-November) are negative and intercept positive. This suggests that trading is more active on December. The result is consistent to findings of Lakonishok and Smidt (1984) based on the U.S. data and supports the hypothesis that seasonal effects observed on stock markets are due to tax-related trading motives at the end of the year. However, most of the dummies are not statistically significant even at the ten percent level, so that role of December as the most active month is statistically at least partly questionable. Trading decreases the most clearly during March/April, July and November. Lower trading on March/April may be explained due to fewer trading days due to major holidays held during those months. July is also one of the most important holiday seasons, and it is probable that many important traders are then having their summer holidays. Monthly dummies do not have any significant impact on market-wide spreads.

In daily regressions explanatory power of seasonal dummies is stronger than in monthly regressions. In daily regressions explaining trading volume weekday dummies Tuesday-Thursday are significantly positive with p-values even below 10^{-15}. According to the coefficients, Tuesday is usually the most active day. Mondays and intercepts are significantly negative. This suggests that trading is the most active in the middle of the week, and the weakest on Fridays and especially on Mondays. These results are consistent with findings of Foster and Viswanathan (1990) based on the U.S. data and Pursiainen (1998) based on Finnish data. Explanation for the phenomenon is based on information asymmetries. Foster and Viswanathan (1990) assume that over a weekend accumulates more private information than on a week night. Hence, they predict that liquidity should be lower on Mondays than other weekdays, as liquidity traders postpone their trades due to high amount of asymmetric information on markets on Mondays. Parameters of market-wide spread regressions are just the opposite except the significance of Monday dummy, indicating high liquidity in the middle of the week. Low Friday liquidity compared to middle of the week also supports findings of Chordia et al. (2001), who report that liquidity is lowest on Fridays, possibly due to fluctuations in investor mood over the week.

Contrary to expectations, closeness of major Finnish holidays does not decrease liquidity on Helsinki Stock Exchange significantly. Coefficients of volume measures are negative, but only one of them is significant even at the ten percent level. Instead, major U.S. holidays indicating potential absence of U.S. investors decrease trading activity significantly. This result is consistent with findings of Pursiainen (1998). Logically, excluding Nokia Corporation owned mainly by foreigners clearly decreases explanatory power of U.S. holidays. However, on bid-ask spreads U.S holidays do not significantly impact. Logical explanation could be lower weight of Nokia, as daily spreads are not value-weighted.

Based on Chow tests in Table 10., same weekly and daily regression models are not optimal during both the first and second half of the data (first half covers years 1990-1994 and first part of 1995, the second part of 1995 and years 1996-2000). On the other hand, the same regression model seem to describe monthly liquidity changes well during the whole data period, but this result is at least partly caused by wide confidence intervals due to low amount of monthly data. In other words, weight of different parameters changes depending the test period. The most probable reasons are differences in trading volume and changed institutional conditions. In addition, there are notable differences in adjusted R^2s between subperiods. Table 11. presents separate regression models for first and second half of the data. Based on the results, signs of the most powerful explanatory factors (equity return, market volatility, weekday dummies) remain similar and significant during the both parts of the data. Instead, signs of other variables noticed to have some explanatory power do not stay stable. Therefore, they are dependent on the data. Logically, impact of US holidays indicating absence of U.S. investors is significant only in the latter part of the data, when their weight is bigger due to changed legislation and foreign interest in Nokia corporation.

Table 9. Time series regressions

Dependent variables are logarithmic changes in market-wide bid-ask spread and trading activity as described in Table 1. Acronyms ArithmeticSpread and ValueSpread denote different measures of market-wide bid-ask spreads, TotalVol, Vol and VolNokiaOff market trading volumes and DefTotalVol, DefVol and DefVolNokiaOff trading volumes deflated by market index. Explanatory variables are as described in Table 2: R_{mt} equity market return, R_{mt-1} lagged equity market return, $Vola_t$ equity market volatility, USD_t change in FIM/USD, $IB3_t$ change in 3-month interest rate $TSpr_t$, change in term spread, $VolaUSD_t$ FIM/USD volatility, $VolaIB3_t$ interest rate volatility, $BondVol_t$ bond market trading volume, January-November monthly dummies, Monday-Thursday weekday dummies, US dummy indicating US holiday and Holiday dummy taking value 1 if the day is preceding or following major Finnish holiday. GLS method is employed to correct autocorrelation of residuals. DW is d-statistic of Durbin-Watson autocorrelation test after correction. Correlation coefficients significant at the 1,5 or 10 percent level based on t test are indicated by ***, ** and *, t statistics in parentheses. Sample sizes are 2751 daily, 571 weekly and 131 monthly, sample period is 1990-2000.

Panel A: Monthly series (131 observations)

Explana-tory variables	ArithmeticSpread Coefficient	ValueSpread Coefficient	TotalVol Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefTotalVol Coefficient	Defvol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-0.788*** (-4.18)	-0.965*** (-4.01)	1.530*** (5.18)	1.446*** (4.14)	1.607*** (4.38)	0.643** (2.21)	0.950*** (2.75)	1.236*** (3.46)
R_{mt-1}	0.111 (0,59)	0.556** (2.30)	0.389 (1.30)	0.482 (1.37)	0.227 (0.61)	0.314 (1.07)	-0.039 (-0.11)	-0.202 (-0.56)
$Vola_t$	7.159** (2,78)	2.304* (1.79)	1.065 (0.41)	6.204** (2.43)	5.484** (2.08)	1.189 (0.55)	6.616** (2.60)	5.608** (2.41)
USD_t	-0.134 (-0,23)	0.316 (0.46)	-0.965 (-1.10)	-0.295 (-0.29)	-0.145 (-0.14)	-0.856 (-0.99)	-0.150 (-0.15)	-0.097 (-0.095)
$IB3_t$	0.438 (1,57)	0.206 (0.62)	-0.422 (-0.98)	-0.717 (-1.46)	-0.788 (-1.54)	-0.408 (-0.96)	-0.686 (-1.41)	-0.595 (-1.20)
$TSpr_t$	-0.016 (-0,34)	-0.077 (-1.34)	-0.151** (-2.04)	-0.214** (-2.52)	-0.196** (-2.21)	-0.148**	-0.211** (-2.51)	-0.184** (-2.14)
$VolaUSD_t$	-9,307 (-1,32)	-8.524 (-1.18)	7,224 (1.10)	15.181** (2.37)	13.193** (2.05)	10.677* (1.82)	16.813** (2.61)	12.224** (2.05)
$VolaIB3_t$	0.356 (0,20)	1.001 (0.67)	1.824 (1.57)	1.320 (0.97)	1.508 (1.13)	1,346 (1.47)	1.636 (1.02)	0.917 (0.77)
$BondVol_t$	-0.018 (-1,20)	-0.018 (-0.84)	0.023 (0.89)	0.001 (0.02)	0.013 (0.40)	0.022 (0.89)	0.002 (0.07)	0.019 (0.62)
January	-0.140 (-1,50)	-0.094 (-0.73)	-0.075 (-0.52)	-0.159 (-0.82)	-0.221 (-1.11)	-0.114 (-0.84)	-0.195 (-1.09)	-0.264 (-1.42)
February	-0.016 (-0,18)	0.007 (0.07)	-0.185 (-1.31)	-0.164 (-0.99)	-0.150 (-0.89)	-0.084 (0.71)	-0.189 (-1.25)	-0.182 (-1.16)
March	0.021 (0,24)	-0.129 (-1.13)	-0.051 (-0.36)	-0.339** (-2.00)	-0.387** (-2.23)	-0.063 (-0.53)	-0.337** (-2.14)	-0.389** (-2.38)
April	-0.028 (-0.32)	0.098 (0.87)	-0.257* (-1.81)	-0.411** (2.46)	-0.311* (-1.81)	-0.266** (-2.24)	-0.407*** (-2.63)	-0.311* (-1.95)
May	0.003 (0.04)	0.024 (0.22)	-0.030 (-0.21)	-0.201 (-1.20)	-0.277 (-1.61)	0.003 (0.02)	-0.206 (-1.33)	-0.292* (-1.82)
June	-0.019 (1.51)	0.058 (0.52)	-0.203 (-1.43)	-0.319* (-1.91)	-0.357** (-2.08)	-0.166 (-1.40)	-0.290* (-1.87)	-0.327* (-2.04)
July	-0.009 (-0.10)	-0.051 (-0.45)	-0.215 (-1.52)	-0.344** (-2.05)	-0.468*** (-2.73)	-0.211* (-1.78)	-0.342** (-2.20)	-0.473***(-2.94)
August	0.003 (0.03)	- 0.035 (0.31)	0.012 (0.08)	-0.123 (-0.74)	-0.022 (-0.13)	0.067 -0.085	-0.085 (-0.55)	0.001 (0.01)
September	-0.019 (-0.21)	0.079 (-0.70)	-0.068 (-0.48)	-0.183 (-1.08)	-0.273 (-1.57)	-0.018 (-0.15)	-0.137 (-0.87)	-0.227 (-1.40)
October	0.084 (0.93)	0.090 (0.85)	0.198 (1.40)	-0.112 (-0.70)	-0.236 (-1.44)	0.191* (1.67)	-0.085 (-0.57)	-0.215 (-1.40)
November	-0.076 (-0.84)	-0.070 (-0.55)	- 0.113 (-0.80)	-0.381** (-2.00)	-0.428** (-2.19)	-0.112 (-0.85)	-0.407** (-2.30)	-0.446** (-2.44)
Intercept	-0.008 (-0.13)	-0.012 (-0.11)	0.108 (1.08)	0.347** (2.26)	0.366** (2.32)	0.100 (0.96)	0.319** (2.24)	0.356** (2.41)
Adjusted R^2	0.267	0.204	0.259	0.271	0.277	0.243	0.203	0.211
DW	1.981	2.131	2.073	2.134	2.159	2.096	2.187	2.189

Panel B: Weekly series (571 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-1,078*** (-6,04)	1,278*** (2,69)	1,584*** (3,13)	0,902** (1,90)	1,154** (2,29)
R_{mt-1}	-0,005 (-0,03)	1,076** (2,23)	0,557 (1,12)	0,446 (0,922)	0,215 (0,43)
$Vola_t$	6,046*** (3,52)	8,244*** (4,23)	7,687*** (3,77)	8,314*** (4,39)	7,886*** (3,88)
USD_t	-0,975 (-1,22)	1,694 (1,46)	0,858 (0,705)	1,610 (1,38)	0,759 (0,53)
$IB3_t$	0,060 (0,31)	-0,215 (-0,39)	-0,387 (-0,66)	-0,218 (-0,39)	-0,332 (-0,57)
$VolaUSD_t$	-1,900 (-0,97)	12,635** (2,40)	15,158** (2,75)	12,858** (2,44)	15,249** (2,78)
$VolaIB3_t$	-0,350 (-0,70)	1,500 (1,06)	1,351 (0,91)	1,497 (1,05)	1,334 (0,90)
Intercept	0,018 (1,25)	-0,111*** (-2,71)	-0,130*** (-3,05)	-0,112*** (-2,73)	-0,129*** (-3,03)
Adjusted R^2	0,166	0,193	0,189	0,175	0,168
DW	2,076	2,117	2,136	2,093	2,047

Panel C: Daily series (2751 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-2,484*** (-8,99)	3,866*** (6,53)	3,959*** (6,28)	2,866*** (4,84)	3,323*** (5,28)
R_{mt-1}	0,935*** (3,42)	-1,531** (-2,62)	-1,555** (-2.50)	-1,534** (-2,62)	-1,604** (-2,58)
$Vola_t$	2,158*** (5,28)	6,713*** (12,73)	5,798*** (6,18)	11,22*** (12,74)	5,789*** (6,18)
USD_t	-0,105 (-0,18)	-0,078 (-0,06)	-0,027 (-0.02)	-0,078 (-0,06)	-0,053 (-0,04)
$IB3_t$	0,227 (1,00)	-0,339 (-0,68)	-0,516 (-0.97)	-0,339 (-0,68)	-0,493 (-0,93)
$VolaUSD_t$	-1,070 (-1,50)	0,829 (0,52)	1,561 (0.94)	0,829 (0,53)	1,518 (0,91)
$VolaIB3_t$	0,101 (0,50)	0,160 (0,36)	0,031 (0.07)	0,160 (0,36)	0,036 (0,08)
US	-0,009 (-0,31)	-0,206*** (-3,29)	-0,113* (-1,69)	-0,206*** (-3,29)	-0,113* (-1,69)
Holiday	0,016 (0,91)	-0,065* (-1,71)	-0,047 (-1,17)	-0,065* (-1,72)	-0,048 (-1,20)
Monday	-0,029 (-1,53)	-0,106*** (-2,54)	-0,130** (-2,94)	-0,106** (-2,55)	-0,130*** (-2,94)
Tuesday	-0,072*** (-4,78)	0,292*** (8,80)	0,318*** (9,01)	0,292*** (8,80)	0,318*** (9,02)
Wednesday	-0,053*** (-3,49)	0,168*** (5,01)	0,125*** (3,50)	0,168*** (5,01)	0,124*** (3,50)
Thursday	-0,037*** (-1,98)	0,147*** (3,56)	0,065 (1,49)	0,147*** (3,56)	0,065 (1,48)
Intercept	0,057*** (3,15)	-0,171*** (-4,30)	-0,131*** (-3,09)	-0,171*** (-4,30)	-0,130*** (-3,09)
Adjusted R^2	0,113	0,171	0,162	0,168	0,161
DW	2,137	2,113	2,097	2,041	2,079

Table 10. Chow tests of time-series regressions

Chow test is used to determine, if time series regressions presented in Table 7. are similar during both the first and second half of the 1990's. The original sample is divided to two samples with 1385 daily, 285 weekly and 65 monthly observations. The first sample covers years 1990-1994 and first half of 1995, the second half of 1995 and years 1996-2000. F statistics significantly different from zero at the 1(5) percent level are indicated by ** (*).

Time series	Monthly	Weekly	Daily
Liquidity variables			
ArithmeticSpread	1,544	5,178**	2,377**
ValueSpread	0,499	-	-
TotalVol	1,559	-	-
Vol	0,926	2,479**	4,032**
VolNokiaOff	1,778	2,667**	4,826**
DefTotalVol	1,379	-	-
DefVol	1,028	2,365*	3,975**
DefVolNokiaOff	1,763	2,512**	4,846**

5.2.2 Robustness of regression models

As presented above, regression model sets several requirements for used data. Using linear regression methodology, error term and parameters should follow normal distribution. Without normality used test statistic may be violated. However, this is not typically controlled, as according to Central Limit Theorem parameters can be assumed to be asymptotically normal, especially with large sample sizes. Similarly, nonzero expected value of error-term is not usually regarded as a serious violation, as it has no effect on slope parameters. (Pindyck and Rubinfield 1997: 145-146)

Autocorrelation of residuals is a typical violation from data requirements in time series studies. Like sample autocorrelation coefficients of used liquidity variables, also relatively high Durbin-Watson statistics (from 2,4 to 2,8) of pure OLS-regressions indicated negative autocorrelation of residuals. Therefore, autocorrelation correction employing generalized least squares was needed. In most of the cases, the most typical correction assuming AR(1) type error process succeeded to decrease Durbin-Watson statistics sufficiently, close to two. In some cases autoregressive error process seemed have more than one lags, but AR(2) type correction was then enough to correct the worst distortions of autocorrelated residuals. Durbin-Watson statistics of corrected regressions are reported in Table 9. in addition to other regression paramenters.

Several White tests assuming that residual variance is dependent on independent variables were tested to control heteroscedasticity, and according to results this type of heteroscedasticity is not a problem in this study. As a matter of fact, this type of heteroscedasticity does not usually occur in time series studies (Pindyck and Rubinfield 1997: 146). Based on visual inspection of residuals, clumping of high and small variances typical to models employing autoregressive conditional heteroscedasticity is not clearly noticeable, but in future studies one might still want to test power of ARCH or GARCH models.

Based on relatively low pair-wise correlation coefficients of explaining variables, multicollinearity should not be a severe problem in this study. For instance, Gujarati (1992: 299) mentions that multicorrelation suspicions based on pairwise correlation require high coefficients, such as over 0,8. Also, regression models do not suffer from a classical multicollinearity symptom, a combination of high R^2 and few significant t-ratios.

As regressing non-stationary time series against others can lead to spurious results, stationarity of used time series was tested augmented Dickey-Fuller unit root tests (Table 6.). According to results, existence of unit root in almost all the series was able to reject at the one percent level. The only exceptions were some monthly volatility series, but they also passed this test at the five percent level. Therefore, spurious regression due to non-stationary time series should not be a severe problem in this study.

Table 11. Time series regressions of subperiods

Dependent variables are logarithmic changes in market-wide bid-ask spread and trading activity as described in Table 1. Acronyms ArithmeticSpread and ValueSpread denote different measures of market-wide bid-ask spreads, TotalVol, Vol and VolNokiaOff market trading volumes and DefTotalVol, DefVol and DefVolNokiaOff trading volumes deflated by market index. Explanatory variables are as described in Table 2: Rmt equity market return, Rmt_{-1} lagged equity market return, $Vola_t$ equity market volatility, USD_t change in FIM/USD, $IB3_t$ change in 3-month interest rate $TSpr_t$, change in term spread, $VolaUSD_t$ FIM/USD volatility, $VolaIB3_t$ interest rate volatility, $BondVol_t$ bond market trading volume, January-November monthly dummies, Monday-Thursday weekday dummies, US dummy indicating US holiday and Holiday dummy taking value 1 if the day is preceding or following major Finnish holiday. GLS method is employed to correct autocorrelation of residuals. DW is d-statistic of Durbin-Watson autocorrelation test after GLS correction. Correlation coefficients significant at the 1,5 or 10 percent level based on t test are indicated by ***, ** and *, t statistics in parentheses. The original sample is divided to two samples with 1385 daily, 285 weekly and 65 monthly observations. The first sample covers years 1990-1994 and first half of 1995, the second second half of 1995 and years 1996-2000.

Panel A: Monthly series (131 observations)

Explanatory variables	ArithmeticSpread Coefficient	ValueSpread Coefficient	TotalVol Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefTotalVol Coefficient	Defvol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-1.483*** (-4.09)	-1.032*** (-3.20)	2.628*** (4.33)	2.427*** (3.11)	2.107*** (2.98)	0.943** (2.11)	1.080** (2.27)	1.161** (2.45)
R_{mt-1}	-0.207 (0.36)	0.322 (1.32)	0.116 (0.21)	0.530 (0.74)	0.577 (0.83)	0.214 (0.37)	0.132 (0.27)	0.402 (0.67)
$Vola_t$	1.124 (1.58)	1.357 (0.79)	-0.178 (-0.31)	3.174 (1.24)	2.894 (1.07)	0.141 (0.29)	3.381 (1.30)	3.557 (1.41)
USD_t	-0.464 (-0.86)	0.216 (0.32)	-0.973 (-0.75)	-0.427 (-0.25)	-0.345 (-0.19)	-0.766 (-0.61)	-0.850 (-0.45)	-0.721 (-0.35)
$IB3_t$	-0.071 (-1.02)	0.048 (0.11)	-0.699 (-0.83)	-0.852 (-0.76)	-0.702 (-0.64)	-0.688 (-0.78)	-0.886 (-0.81)	-0.795 (-0.70)
$TSpr_t$	0.124 (0,08)	-0.074 (-1.27)	-0.230** (-2.10)	-0.282* (-1.96)	-0.311** (-2.11)	-0.188* (-1.90)	-0.271* (-1.98)	-0.287* (-2.12)
$VolaUSD_t$	-3,728 (-0.33)	-10.091** (-2.52)	1.247 (0.31)	9.067* (1.77)	8.704* (1.71)	1.677 (0.45)	8.363* (1.69)	8.678* (1.82)
$VolaIB3_t$	2.374 (0.82)	1.701 (1.50)	2.124** (2.11)	1.122 (1.27)	1.213 (1.39)	1,913* (1.77)	1.336 (1.34)	0.983 (1.07)
$BondVol_t$	-0.056 (-1.62)	-0.048 (-1.48)	0.117* (1.91)	0.094 (1.22)	0.082 (1.10)	0.122* (1.95)	0.057 (0.77)	0.087 (1.22)
January	-0.121 (-1.30)	-0.003 (-0.03)	-0.035 (-0.26)	-0.137 (-0.72)	-0.169 (-1.04)	-0.014 (-0.12)	-0.123 (-0.76)	-0.176 (-1.08)
February	0.021 (0.26)	0.139 (1.20)	-0.153 (-0.84)	-0.174 (-1.09)	-0.160 (-0.97)	-0.103 (0.67)	-0.147 (-0.87)	-0.135 (-0.88)
March	-0.043 (0.46)	0.045 (0.48)	-0.044 (-0.32)	-0.357** (-2.41)	-0.349** (-2.04)	-0.073 (-0.56)	-0.334** (-2.06)	-0.335** (-2.10)
April	-0.052 (-0.58)	0.021 (0.20)	-0.257* (-1.88)	-0.414*** (-2.76)	-0.391* (-2.42)	-0.236* (-1.73)	-0.431*** (-2.45)	-0.423** (-2.34)
May	0.047 (0.52)	0.078 (0.68)	-0.022 (-0.16)	-0.171 (-1.04)	-0.137 (-0.86)	0.006 (0.04)	-0.181 (-1.10)	-0.147 (-0.92)
June	0.107 (1.11)	-0.061 (-0.55)	-0.227 (-1.53)	-0.311* (-1.84)	-0.317*(-1.88)	-0.196 (-1.44)	-0.269* (-1.85)	-0.278* (-1.77)
July	-0.029 (-0.34)	0.063 (0.57)	-0.175 (-1.30)	-0.365** (-2.36)	-0.354** (-2.13)	-0.201 (-1.57)	-0.362** (-2.19)	-0.343** (-2.10)
August	0.013 (0.17)	-0.082 (0.74)	0.042 (0.31)	-0.154 (-0.83)	-0.122 (-0.67)	0.028 (0.20)	-0.097 (-0.57)	-0.056 (0.37)
September	-0.029 (-0.34)	0.040 (0.43)	-0.060 (-0.45)	-0.176 (-1.09)	-0.193 (-1.27)	-0.023 (-0.16)	-0.145 (-0.94)	-0.132 (-0.81)
October	0.081 (0.92)	-0.066 (-0.59)	0.156 (0.84)	-0.103 (-0.66)	-0.136 (-0.76)	0.174 (1.06)	-0.122 (-0.72)	-0.152 (-0.95)
November	-0.058 (-0.63)	-0.008 (-0.09)	-0.132 (-0.77)	-0.331* (-1.94)	-0.328* (-1.98)	-0.072 (-0.48)	-0.352** (-2.15)	-0.371** (-2.21)
Intercept	-0.014 (-0.17)	-0.013 (-0.14)	0.167 (1.19)	0.367** (2.37)	0.356** (2.26)	0.171 (1.20)	0.341** (2.12)	0.354** (2.18)
Adjusted R^2	0.153	0.114	0.167	0.158	0.161	0.122	0.124	0.126
DW	1.941	2.171	2.196	2.118	2.142	2.157	2.201	2.174

Panel B: Monthly series, period 2 (65 observations)

Explanatory variables	ArithmeticSpread Coefficient	ValueSpread Coefficient	TotalVol Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefTotalVol Coefficient	Defvol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-0.501** (-2.19)	-0.856** (-2.10)	1.116*** (3.96)	0.827*** (2.73)	0.734** (2.53)	0.722** (2.14)	0.680** (2.10)	0.642** (2.01)
R_{mt-1}	0.228 (1.03)	0.726* (1.72)	0.243 (0.86)	0.278 (0.74)	0.311 (0.95)	0.202 (0.55)	0.261 (0.65)	0.145 (0.47)
$Vola_t$	5.177*** (2.86)	4.126 (2.17)	4.675** (2.17)	7.413*** (3.15)	6.388*** (2.87)	4.923** (2.27)	7.201*** (3.20)	6.412*** (2.81)
USD_t	-0.173 (-0.20)	-0.817 (-0.55)	-1.301 (-1.30)	-0.679 (-0.60)	-0.311 (-0.43)	-0.886 (-0.89)	-0.434 (-0.41)	-0.197 (-0.25)
$IB3_t$	0.438 (1.07)	-0.338 (-0.48)	-0.228 (-0.47)	-0.129 (-0.24)	-0.113 (-0.15)	-0.108 (-0.20)	-0.142 (-0.32)	-0.087 (-0.18)
$TSpr_t$	-0.119 (-0.78)	-0.310 (-1.03)	-0.213 (-1.05)	-0.287 (-1.25)	-0.178 (-0.90)	-0.132 (-0.65)	-0.234 (-1.09)	-0.158 (-0.77)
$VolaUSD_t$	5.223 (-0.93)	3.024 (-0.67)	7.287 (1.43)	6.227 (1.12)	6.407 (1.24)	6.711 (1.31)	6.717 (1.23)	6.023 (1.10)
$VolaIB3_t$	-0.723 (-0.88)	-0.677 (-0.72)	0.554 (0.64)	1.017 (0.94)	0.821 (0.83)	0.671 (0.78)	0.898 (0.85)	0.764 (0.70)
$BondVol_t$	-0.008 (-0.48)	-0.024 (-0.72)	-0.005 (-0.07)	-0.022 (-0.91)	-0.032 (-1.19)	-0.012 (0.55)	-0.021 (-0.84)	-0.034 (-1.16)
January	-0.124 (-1.31)	0.008 (0.10)	-0.067 (-0.50)	-0.137 (-0.64)	-0.223 (1.13)	-0.013 (0.26)	-0.156 (-1.17)	-0.165 (-1.30)
February	-0.004 (-0.05)	0.122 (1.21)	-0.123 (-0.95)	-0.184 (-1.17)	-0.176 (-1.03)	-0.122 (-0.97)	-0.178 (-1.36)	-0.115 (-0.98)
March	0.067 (0.70)	-0.089 (-0.78)	0.021 (0.14)	-0.352** (-1.97)	-0.319* (-1.93)	-0.052 (-0.41)	-0.321** (-2.06)	-0.310* (-1.88)
April	-0.015 (0.21)	0.032 (0.24)	-0.273* (-1.94)	0.411** (-2.41)	-0.364** (-2.08)	-0.256* (-1.74)	-0.393** (-2.46)	-0.387** (-2.33)
May	0.066 (0.66)	-0.088 (0.80)	-0.044 (-0.46)	-0.123 (-0.57)	-0.097 (-0.49)	-0.003 (-0.04)	-0.162 (-1.39)	-0.176 (-1.44)
June	0.127 (1.33)	0.074 (0.64)	-0.257* (-1.83)	-0.267* (-1.74)	-0.322* (-1.96)	0.199 (-1.44)	-0.212* (-1.69)	-0.234* (1.75)
July	0.039 (0.41)	0.079 (0.70)	-0.165 (-1.53)	-0.354** (-2.24)	-0.378**(-2.11)	-0.138 (-1.24)	-0.332** (-2.10)	-0.313* (-1.93)
August	-0.024 (-0.18)	-0.044 (0.37)	-0.062 (-0.47)	-0.147 (-0.72)	-0.104 (-0.54)	-0.031 (-0.40)	-0.123 (-1.06)	0.045 (0.42)
September	-0.039 (-0.40)	-0.087 (0.76)	-0.081 (-0.72)	-0.177 (-1.10)	-0.181 (-1.34)	0.134 (1.15)	-0.134 (-1.18)	-0.148 (1.30)
October	0.064 (0.65)	-0.091 (-0.80)	0.086 (0.81)	-0.121 (-0.99)	-0.168 (-1.23)	-0.065 (-0.53)	-0.170 (-1.40)	-0.098 (-0.86)
November	-0.056 (0.54)	-0.072 (-0.64)	-0.073 (0.77)	-0.311* (-1.92)	-0.308* (-1.84)	-0.104 (-0.86)	-0.323** (-2.04)	-0.321** (-2.07)
Intercept	-0.023 (-0.30)	-0.022 (-0.25)	0.121 (1.04)	0.377** (2.12)	0.366** (2.07)	0.099 (0.93)	0.354** (2.16)	0.331* (1.97)
Adjusted R^2	0.123	0.036	0.088	0.143	0.129	0.052	0.102	0.094
DW	2.037	2.066	2.186	2.045	2.118	2.112	2.102	2.234

Panel C: Weekly series, period 1 (285 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-2,851*** (-7.85)	3,754*** (3.32)	3.803*** (3.27)	1,632*** (2.70)	1,473*** (2.63)
R_{mt-1}	0,470 (1.38)	1,527 (1.05)	1.24 (1.14)	0,324 (0.73)	0,274 (0.63)
$Vola_t$	4,287*** (3.28)	6,012*** (3.59)	5,217*** (3.85)	6,113*** (3.87)	5,402*** (4.03)
USD_t	-0,689 (-1.22)	-0,183 (-0.10)	0.134 (0.07)	-0,221 (-0.16)	0,191 (0.12)
$IB3_t$	-0,450* (-1.83)	0,488 (0.63)	0,397 (0.50)	0,321 (0.44)	-0,332 (0.46)
$VolaUSD_t$	-1,566 (-0.61)	15,642** (1.98)	14.892* (1.84)	14,821* (1.87)	14,489* (1.81)
$VolaIB3_t$	-0,281 (-0.45)	1,812 (0.37)	1.509 (0.73)	1,523 (0.29)	2,145 (0.93)
Intercept	-0,063** (-2.05)	-0,152** (-2.21)	-0,115** (-2.04)	-0,137** (-2.13	-0,103** (-1.97)
Adjusted R^2	0,201	0,221	0,217	0,181	0,175
DW	2,145	2,087	2,178	1,976	2,082

Panel D: Weekly series, period 2 (285 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-0,414** (-2.11)	1,032** (1.99)	0,753* (1.75)	0,688* (1.71)	0,576 (1.22)
R_{mt-1}	-0,136 (-0.69)	-0,125 (-0.27)	-0,083 (-0.16)	0,223 (0.43)	0,274 (0.70)
$Vola_t$	5,122*** (4.19)	6,869*** (6.35)	5,556*** (2.76)	6,741*** (6.22)	5,478*** (2.64)
USD_t	-2,142*** (-4.10)	4,345*** (2.71)	1,669 (0.95)	3,766** (2.45)	1,753 (1.01)
$IB3_t$	0,569 (1.58)	-0,202 (-0.23)	-0,777 (-0.78)	-0,145 (-0.16)	-0,534 (-0.63)
$VolaUSD_t$	-2,654 (-0.68)	8,879 (1.03)	14,327 (1.51)	7,867 (0.87)	12,765 (1.21)
$VolaIB3_t$	-0,582 (-0.51)	5,033* (1.73)	5,063 (1.58)	5,266* (1.85)	4,467 (1.35)
Intercept	0,024 (0.91)	-0,086 (-1.36)	-0,121* (-1.74)	-0,117 (-1.72)	-0,095 (-1.49)
Adjusted R^2	0,126	0,205	0,143	0,157	0,092
DW	2,176	2,154	1,945	2,132	1,925

Panel E: Daily series, period 1 (1385 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-4,945*** (-9.00)	11,372*** (7.09)	10,376*** (6.41)	6,646*** (3.72)	6,253*** (3.45)
R_{mt-1}	2,734*** (5.01)	-4,424*** (-2.77)	-3,117* (-1.93)	-2,774** (-2.12)	-2,432* (-1.88)
$Vola_t$	3,929*** (4.73)	13,783*** (5.67)	13,974*** (5.70)	12,315*** (5.31)	12,015*** (5.17)
USD_t	-0,436 (-0.64)	0,704 (0.36)	-0,462 (-0.23)	0,714 (0.34)	-0,442 (-0.21)
$IB3_t$	0,257 (1.12)	-0,314 (-0.46)	-0,489 (-0.71)	-0,241 (-0.37)	-0,456 (-0.66)
$VolaUSD_t$	-0,434 (-0.53)	-1,376 (-0.59)	-0,214 (-0.09)	-1,214 (-0.52)	-0,456 (-0.17)
$VolaIB3_t$	0,076 (0.36)	0,164 (0.27)	-0,128 (-0.20)	0,162 (0.28)	0,078 (-0.16)
US	0,020 (0.53)	-0,164 (-1.54)	-0,153 (-1.42)	-0,172 (-1.56)	-0,155 (-1.45)
Holiday	0,020 (0.90)	-0,079 (-1.22)	-0,048 (-0.73)	-0,079 (-1.18)	-0,049 (-0.74)
Monday	-0,026 (-1.05)	-0,045 (-0.63)	-0,083 (-1.14)	-0,042 (-0.54)	-0,082 (--1.12)
Tuesday	-0,070*** (-3.58)	0,333*** (5.82)	0,297*** (5.14)	0,331*** (5.57)	0,295*** (5.09)
Wednesday	-0,056*** (-2.83)	0,173*** (3.01)	0,102** (1.76)	0,168*** (2.96)	0,102** (1.76)
Thursday	-0,054** (-2.22)	0,159** (2.24)	0,097 (1.35)	0,157** (2.27)	0,099 (1.36)
Intercept	0,037** (1.60)	-0,166** (-2.42)	-0,115* (-1.66)	-0,170** (-2.47)	-0,111* (-1.64)
Adjusted R^2	0,123	0,145	0,127	0,138	0,121
DW	2,116	2,175	2,084	2,156	2,148

Panel F: Daily series, period 2 (1385 observations)

Explanatory variables	ArithmeticSpread Coefficient	Vol Coefficient	VolNokiaOff Coefficient	DefVol Coefficient	DefVolNokiaOff Coefficient
R_{mt}	-1,905*** (-5.56)	1,777*** (3.72)	1,892*** (3.28)	1,345*** (2.72)	1,445*** (2.90)
R_{mt-1}	0,543 (1.61)	-1,009** (-2.15)	-1,409** (-2.50)	-1,091** (-2.22)	-1,342** (-2.23)
$Vola_t$	1,856*** (3.67)	9,847*** (13.86)	3,069*** (3.58)	9,456*** (13.11)	3,171*** (4.22)
USD_t	-0,004 (-0.00)	-0,935 (-0.60)	-0,027 (-0.01)	-0,923 (-0.53)	-0,032 (-0.02)
$IB3_t$	0,083 (0.14)	0,827 (0.98)	0,001 (0.00)	-0,823 (0.91)	0,002 (0.00)
$VolaUSD_t$	-2,592 (-1.70)	-0,924 (-0.40)	-0,497 (-0.18)	-0,926 (-0.48)	-0,521 (-0.21)
$VolaIB3_t$	-0,062 (-0.12)	0,029 (0.04)	0,751 (0.82)	0,033 (0.06)	0,749 (0.77)
US	-0,045 (-1.03)	-0,220*** (-3.44)	-0,056 (-0.73)	-0,220*** (-3.46)	-0,063 (-0.86)
Holiday	0,007 (0.25)	-0,043 (-1.14)	-0,048 (-1.06)	-0,044 (-1.16)	-0,051 (-1.11)
Monday	-0,034 (-1.18)	-0,161*** (-3.88)	-0,168*** (-3.36)	-0,161*** (-3.94)	-0,167*** (-3.36)
Tuesday	-0,070*** (-3.06)	0,243*** (7.36)	0,335*** (8.40)	0,230*** (6.78)	0,335*** (8.41)
Wednesday	-0,048** (-2.06)	0,153*** (4.59)	0,147*** (3.64)	0,168*** (4.85)	0,148** (3.64)
Thursday	-0,013 (-0.45)	0,125*** (3.04)	0,039 (0.80)	0,124*** (2.89)	0,042 (0.83)
Intercept	0,067** (2.37)	-0,130*** (3.18)	-0,121** (-2.45)	-0,122*** (2.96)	-0,120** (-2.43)
Adjusted R^2	0,080	0,204	0,171	0,178	0,145
DW	2,114	2,143	2,059	2,166	2,094

6 Summary and conclusions

This study concentrates on time-series qualities of market-wide liquidity measures and their determinants on Helsinki Stock Exchange 1990-2000. Existing research on how the aggregate market liquidity varies over time is relatively limited, especially on limit order book markets like Helsinki Stock Exchange. Market-wide trading volume and bid-ask spreads composed of single stocks are used as liquidity measures.

Aggregate bid-ask spreads and trading volume are even more volatile than market returns. Daily, weekly and monthly changes in liquidity measures are negatively autocorrelated and deviate from normal distribution. During the 1990's liquidity on Helsinki Stock Exchange has increased considerably. Potential originator of increased liquidity is a notable rise in equity prices from the beginning of the 1990's fuelled by economic growth and boom of high-tech stocks at the end of 1990's. In addition, in the 1990's Finnish equity market has overcome several institutional changes. With the liberalization process of Finnish financial markets, Finnish stocks have become more interesting to foreign investors. Removal of tax disadvantage of equity investments and decreased importance of bank and other intermediated finance have probably also increased interest in stock markets.

Market liquidity was find to be influenced by several factors. Based on existing literature and intuitive reasoning, candidates as possible determinants were nominated. The explanatory variables include equity market return, market volatility, interest and exchange rates and their volatility, term spread, trading activity of Finnish bond market and indicators for holiday effects, for the day of the week and for the month. The connection is studied with time series regressions on daily, weekly and monthly frequency. The determinants investigated explain between 20 and 28 percent of monthly, between 17 and 19 percent of weekly and between 14 and 17 percent of daily changes in market liquidity. R^2s and weight of different explanatory variables varies depending on used subperiod of the data.

Consistent with the U.S. results, trading is more active on bullish market on all data frequencies. Logically, this also decreases spreads on bullish market due to increased competition between investors. According to existing theoretical literature, costly short selling and different aspects of market psychology are behind the phenomenon. Equity market return is clearly the most powerful explanatory variable of monthly regressions.

Similarly consistent with several earlier results, trading is more active during considerable price changes. This connection increases notably with data frequency. In existing theoretical literature this connection is usually explained by information announcements: interesting unexpected information contemporaneously increases trading and causes price changes. However, increased trading during high volatility does not decrease spreads, as they then tend to increase. This result is consistent with studies showing that individual share volatility is cross-sectionally associated with higher spreads due to problems related to uncertainty and asymmetric information.

In addition to equity returns and volatility, weekday and U.S. holiday dummies are significant determinants of market liquidity. Liquidity is the most active in the middle of the week and weakens on Friday and especially on Monday. Major U.S. holidays indicating absence of U.S. investors decreases trading on Helsinki Stock Exchange significantly. Some indications of monthly regularities of trading activity also exist. Trading decreases the most clearly in March/April, July and November and increases on December. Also term spread and exchange rate volatility have statistically significant connection with monthly variation of trading activity. Other variables do not have a clear connection with market liquidity.

Based on this study, several suggestions for further research on time series behaviour of market liquidity can be presented. It was noted that all measures of market liquidity do not correlate well with each other. Especially correlation between market-wide bid-ask spread and trading activity on higher data frequencies was very small. This may be due to use of fourchettes based on daily close bid and ask quotations as bid-ask spreads. If these two basic measures of market liquidity deviate so much with each other, several questions considering reliability of measuring market liquidity as a concept can be presented. Therefore, using additionally more sophisticated liquidity measures, like depth, breadth and effective spreads (see e.g. Hedvall 1994 and Koivisto 1998) may give additional information.

In addition, some new explaining variables can be added. For instance, reactions of liquidity to different information announcements would be interesting from the viewpoint of both independent securities and the whole market. Clarifying implications of liquidity issues for asset pricing can also be fruitful. For example, possible connection of unexpected liquidity changes with risk premia could be a potential cross-sectional determinant of asset returns. In addition to empirical studies, current theoretical understanding considering liquidity variation and its determinants is relatively limited.

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